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~~Harry A. Sleeter~~

# Missouri River Basin

## AGRICULTURAL PROGRAM

A program recommended by Secretary of Agriculture Charles F. Brannan for the development and conservation of land, water, and forest resources, and for flood control in the Missouri River Basin

UNITED STATES DEPARTMENT OF AGRICULTURE  
APRIL 1949



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MISSOURI RIVER BASIN AGRICULTURAL PROGRAM

Summary of the Recommendations

By Secretary of Agriculture Charles F. Brannan

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# MISSOURI RIVER BASIN AGRICULTURAL PROGRAM

## Summary of the Recommendations

Nearly two years ago, President Truman, in a message to the Congress, declared that "the major opportunity to increase the wealth of the Nation lies in the development of our great river systems."

We can find no better example of this truth than the great basin of the Missouri River--the country's largest single river. Its waters flow from ten States and drain one-sixth of the country's total land area, one fourth of its farmland.

Most surely the wealth of the Nation will grow with the development of the Missouri Basin. But its development is equally imperative if we are to preserve the resources with which the basin is richly endowed and assure their full employment for the continuing good of the people.

These are the goal and the challenge to which we, as a Nation, must devote the full measure of our skill and our energy with enough money to accomplish the task. The first essential is a plan. This is to be found in detail in the report, "Missouri River Basin Agricultural Program." It has been prepared by the Department of Agriculture as a result of its participation in the Missouri Basin Inter-Agency Committee and the active encouragement the Department has had from the Missouri Basin States Committee. The Land-Grant colleges of the basin have co-operated in the preparation of certain aspects of the program.

The report is a new and outstanding landmark in planning for the continuous development, conservation, and use of our assets in land, water, and forests in our river systems. But it is even more noteworthy for its recognition of the responsibilities and the needs of the people, the Missouri Basin and their State governments and institutions. Progress and success will reward our efforts in direct proportion to the cooperative effort we enlist in the proper management of our land resources. This is one of the principles upon which the program is founded.

A stable foundation for agriculture in all its aspects in a region where drought is an unusually high risk in farming is, of course, a primary target of the program. But it is also designed in all its parts to contribute to flood control in all the major and minor valleys of the basin. Better water supplies, an enlarged and sustained lumbering industry, and new and better opportunities for recreation are a few of the program's many other attainable accomplishments and serve to illustrate its scope.

By its careful design, the program will enlarge the wealth of benefits the Nation rightly expects from our increasingly large investment of public money in dams, reservoirs, and other huge engineering works in the basin. The agricultural program will protect these works



and give them longer life, and, at the same time, aid farmers and farm families in using the expected benefits to better advantage. But the program is more than an insurance policy on the engineering plan incorporated in the Flood Control Act of 1944. Full-fledged development in all parts of the Basin is the Nation's guaranty that we are combating the loss and ruin of our natural resources wherever they are endangered.

The key to the most advantageous sustained use of the resources of the basin is its climate. Our experience in the basin runs for a little more than a century. Three times within this period severe and prolonged droughts have afflicted the region. The first came before the days of settlement. But the others have left an imprint on the land and in our history. Ruined resources are one measure of the price we have paid for unwise land uses which heighten the impact of the extreme fluctuations in the weather. Another is to be found in the human hardships inflicted by a barren land. These great droughts have been spaced thirty to forty or more years apart, but the intervening spans have often been marked by shorter periods of bad weather.

The good weather the basin has enjoyed for nearly a decade has been the Nation's good fortune as well as the basin's. The span coincided with our success in the Second World War, and the basin unsparingly contributed its bounty to our war effort. But, if the drought of the 1930's had been prolonged a few more years, the Missouri Basin would have been incapable of giving its support to the rest of the Nation.

Unwise management of land and poor land and cropping practices are common throughout the basin. These are in part concealed and in part encouraged by the blessing of good weather. As a result, deterioration goes on largely unchecked in our resources, and the basin is becoming increasingly vulnerable to the unpredictable advent of another great drought. We should be using the good years to prepare for the bad.

The agricultural program will enable the people of the basin to take advantage of the present opportunity to conquer erosion and end depletion, to develop and improve their resources in land and forests, to employ them in full, and to enjoy their benefits in better and more secure living. Whether we conserve and use our resources in this rewarding manner will be determined ultimately and with finality by what the people themselves do with their land. This is particularly true in the Missouri Basin where 79 percent of the land is privately owned.

In its design and its operating principles, the program recognizes that its success will be determined in the end by the ability and the capacity of farmers and land owners to fulfill their responsibilities in land management. The program likewise recognizes that the government does not operate directly on land in private hands except by agreement with land owners. But the program also recognized that all farmers and



land owners, by and large, are willing to apply the best in practical land treatment--not only because it assures conservation of our resources, but also because it enriches productivity and contributes to security in land values.

These principles, in the main, have guided the Department in the preparation of this program. As a result, we are confident that it will have at its command the voluntary support and cooperation of farmers, land owners, farm groups and organizations, and the State governments of the basin. Without their participation, this program or any other plan for the basin's comprehensive development will be largely worthless.

The program is truly novel in its magnitude, but the principles it recommends and eventually will apply throughout the basin are familiar, time-tested, scientific practices and structures. The program offers no startling innovation in land use or in the Department's logical and usual role in conserving our land resources and controlling the flow of water. The body of the program represents numerous functions, services, activities, and direct undertakings which the Department already has under way in some measure in the basin and, to the extent to which they are appropriate, everywhere in the United States. The unique qualities of the program are to be found in its coordination of land management for conservation and flood control, in its integration of diversified services in order to achieve a common goal, and in its recommendations for a much swifter pace in conservation and the adoption of constructive land management.

Even with this acceleration, at least thirty years will be needed to complete the task of developing the basin's agricultural resources. At the present rate of progress, however, the desirable results may be delayed for as long as a century, if, in fact, we are able to realize them at all. This is a good measurement of the size and intensity of the challenge of wasted and wasting resources in the basin. The cumulative design of the program anticipates, of course, an ever-larger flow of discernible benefits from the very beginning of the development period.

The program will go forward on five major operating fronts in which the emphasis will be largely upon the management and use of our land resources for conservation and flood control. The program will likewise encourage the development and employment of these resources in their most economic use. The program contemplates the installation of essential small-scale engineering works to control the flow of water on its way to the Missouri River and its larger tributaries. The construction of roads and other facilities have their proper place in assuring the full use of our national forests for lumbering and recreation.



These five operating divisions have a common basis in the fundamental inter-relationship in land use so that the progress in each is essential to progress in all. These divisions are, as follows:

1. Conservation and improvement measures on grassland and cropland. Here the program is designed to reach all the 582,000 farmers and ranchers in the basin. The goal, reduced to its simplest terms, is the application of good land management and conservation practices to the basin's 282,000,000 acres in farms and ranches. Such a program will stabilize and increase production, reduce erosion and sediment damage, abate floods and produce many other kinds of benefits. It is, therefore, a truly multiple-purpose program.
2. Forests and forest ranges. Here the program will be concerned with the development and management and use of the resources in public lands as well as those in private ownership. Federal agencies are responsible for nearly 80 percent of the 72,000,000 acres in public ownership. These federal forest lands found largely in the western reaches of the basin, especially in the Rocky Mountains, are the source of a substantial share of the water which flows through the States of the upper watershed and the Western Plains. This imposes upon the federal government the responsibility to accelerate conservation and flood control to the same degree that private owners will be requested to do so elsewhere in order to secure the maximum control of floods and sediment at their sources. The development of the public lands will prove of direct material value to the livestock, lumbering, and recreation industries of the basin.

On private lands the program aims to achieve forest practices which will restore and sustain productivity of the land and its capacity to retard runoff and prevent erosion.

3. Stabilizing measures for small watercourses. Here the program will assure the safe disposal of water in small watersheds and the lesser tributary streams. This will contribute to flood control, to the protection of the public investment in large flood control works, and to the protection of lands being destroyed by major gullies, bank-cutting and sedimentation. The program contemplates the construction of gully control structures, floodways, bank protection works and small retarding basins.



4. Irrigation. Here the program will aid farmers in increasing by two and a half times the basin's irrigated farmland. At present, about 5,000,000 acres are irrigated. The construction projects of the Bureau of Reclamation of the Department of Interior will provide water for another 5,000,000 acres in new irrigation and supplemental water for the operation of 1,500,000 acres in existing irrigation districts. Another 1,000,000 acres will be irrigated with water from other sources. This will give the basin 12,500,000 acres in irrigation. The number of irrigated farms will be increased from about 38,000 to upwards of 75,000 and will then represent about 12.5 percent of the farms in the basin. Acute land use and farm management problems, however, are present in the development of irrigation projects, especially in the transition from dryland farming. The responsibility of the Department of Agriculture includes, moreover, the kind of assistance that will not only assure good irrigation, but also prevent the waste of land resources through poor practices.
5. Drainage. Here the program will help farmers renew the usefulness of impaired drainage systems and improve drainage on lands not now used to the best advantage. The program is essential, moreover, to assure the installation of drainage systems for nearly 1,500,000 acres of wet land which will be relieved of the menace of periodic flooding when the levee system of the Corps of Engineers of the Department of the Army is completed along the Missouri River below Sioux City, Iowa. The basin contains, in all, more than 5,800,000 acres of land requiring some degree of drainage to insure full production. About half of the existing drainage systems are in poor working condition.

Irrigation and drainage are, of course, specialized problems which affect relatively few farmers and land owners. However, these problems must be solved if we are to achieve the comprehensive development of the basin and assure the conservation of our resources. The irrigation and drainage divisions of the agricultural program are, nevertheless, basin-wide in their approach to these problems.

But the major aspects of the program are to be found in the application of conservation practices and good land use measures to farms and ranches, in the improvement of forests and forest ranges, and in the stabilization of stream flows. These programs deal directly with the use and management of land, water, and forests.

The program will be accomplished, in the main, by encouraging farmers and private owners to protect their land from erosion and depletion and to operate their farms and ranches so as to withstand the punishment adverse weather inflicts on land and people. In making and applying practical conservation plans, farmers, ranchers, and land owners will have available to them the best technical assistance the federal government can furnish through its services and in cooperation with the appropriate agencies of the States. In addition, farmers, ranchers, and land owners will be reimbursed in part for the cost of the initial installation and application of those practices. This employment of public funds is much more than a mere incentive to gain cooperation and participation.

Partial reimbursement recognizes first that many benefits accrue directly to the public from these installations and practices. Among these benefits are conserved resources, flood control, better water supplies, enhanced recreational opportunities, and the reduced need for public assistance in the event of adverse weather. In some instances, moreover, new installations and practices require major adjustments in farm operations and the momentary loss of farm income.

For these reasons, the public should share first costs in the appropriate degree. This practice is now employed through the United States by the Department of Agriculture. Under the program proposed for the Missouri Basin, the practices would be accelerated in keeping with the urgency of the problems of conservation and land use in the basin and to aid in its full-scale development.

But the program provides still other means to establish good land management in the basin. Intensified extension education, rural electrification, and research will give their essential support to the program.

Special credit resources are required to supplement private credit agencies in view of the expectation that farmers, ranchers, and land owners will invest three to four dollars for every dollar of federal funds expended for conservation. The increased availability of public credit is recommended with the understanding that the use of commercial credit sources will be encouraged in operating the program. In any event, expanded credit facilities are essential to the development and improvement of irrigation and drainage systems which often require types of credit unavailable from private lenders.

Another essential supporting service is the complete survey of the soils of the basin and the classification of its land. This information will assure the employment of lands in their best adapted uses, but it is imperative to the extension of irrigation and drainage systems. This soils information, it is worth noting, has a continuing value far beyond its usefulness in this program.



With these supporting efforts in research, electrification, credit, and extension education, the program represents a unified agricultural approach to the development of river basins in America. Conservation, flood control, land management, and the general development of agriculture are in essence the same from this approach, and they cannot be treated in fractions and in fragments with any genuine hope of complete and permanent success. This is implicit in the program which, of necessity, treats land and water as the inseparable elements of our agricultural resources.

The dimensions of the program, however, are best illustrated by the major achievements to be expected at the end of thirty years of accelerated effort.

Improved land management, for instance, is advisable on a large part of the basin's 113,000,000 acres of cropland to assure their employment in the best adapted uses, to control erosion and halt depletion, and to retard flood waters at their very source.

This means the seeding of grass and legumes on 20,000,000 acres where continuous cultivation is depleting fertility and accelerating erosion. This, in turn, means more and larger livestock enterprises in the basin.

Green manure and cover crops are needed every year to protect 13,000,000 acres of barren cropland from wind and water erosion as well as to add to the soil's fertility.

Stubble mulching is needed yearly to increase the amount of water absorbed by 34,000,000 acres of grain crops and to prevent wind and water erosion from carrying away the soil.

Strip cropping and contour farming systems are needed on 63,500,000 acres for similar reasons.

These various practices, some of which are applicable on the same land, must be fortified with 1,900,000 miles of terraces to retain water or to dispose of it in safety.

Similarly complete treatment is needed on the basin's 157,500,000 acres of privately owned range and pasture land. This includes reseeding 17,500,000 acres with grass and legumes, adjusting livestock to carrying capacity on 117,300,000 acres, and the use of seasonal grazing on 7,700,000 acres.

The full development of potential stockwater supplies are essential to the uniform use of grazing, better growth of grass and legumes, and less erosion. This means the construction, improvement, and use of more than 500,000 new ponds, 30,000 springs and seeps, and 73,000 wells for water. Grazing land also must be protected with 166,000 miles of fire



guards (10-foot wide strips of turned or chemically treated soil to control fires), 65,000 miles of new fencing, and 2,000 miles of new cattle trails.

Forests and forest ranges are resources with many uses -- for timber, for grazing, for recreation and wildlife, and for the protection of water supplies. The program is designed to improve the forests and the ranges so as to achieve the maximum uses. Tree planting, for instance, is contemplated on 5,000,000 acres of forests and the reseedling of 400,000 acres of forest range. New roads are planned to permit lumbermen to harvest mature stands in inaccessible regions of the Rocky Mountains. It contemplates the construction of lookout towers, roads, trails, and fire crew stations to provide for more intensive fire protection. In addition the program contemplates the planting of more than 2,500,000 acres of shelterbelts and windbreaks to conserve moisture, check wind erosion, and protect crops, livestock, and farmsteads.

The stabilization of small watercourses, the third major aspect of the program, will reinforce land use practices and treatments designed to hold water on the land and ease it forward to main stream channels without overflow. These stabilization measures are of greatest importance in meeting the challenge of rains of high intensity and high frequency, flash floods, and rapid snow-melting. Saturated or frozen ground adds to the problem and the erosion and floodwater damage that can result.

Between 14,000 and 16,000 small upstream dams are planned along with 400 to 600 desilting and debris basins. The dams will provide temporary storage for 4,800,000 acre-feet of water distributed throughout the basin on drainage areas of less than 50 square miles.

Additional stabilization measures include 4,500 to 5,500 miles of minor floodways, 10,000 to 12,000 miles of small stream channel improvements, and 60,000 to 70,000 miles of diversion ditches and dikes to route flood water from eroded land and terraced fields.

There is no magic and no wizardry in this effort. It proposes to strive toward what nature, under the most ideal conditions, does to replenish and strengthen renewable resources. The challenge we face is the accomplishment of the same result at the same time that we use our land, water, and forests to fulfill our needs in food, clothing, and shelter, in safer and more secure living, and in assuring better means of a livelihood. In its accumulative effort, the program will achieve these goals. But it will require continuous and coordinated work on all the land in the Missouri Basin. This means, in effect, that the private lands in the basin will be protected and developed by the farmers, ranchers, and land owners operating on their own land as their own program managers with the accelerated active assistance of government.

The cost to the federal government of installing the entire recommended program is estimated at \$3,092,328,000. The distribution of this cost among the operating and supporting divisions of the program is shown in the following table:

Summary of Estimated Costs to the Federal Government  
of Installing the Recommended Program

Program of Conservation and Improvement Measures	
for Grassland and Cropland .....	\$ 1,189,630,000
Program for Forest and Forest Range Lands .....	493,609,000
Program of Stabilizing Measures for Small Watercourses ....	1,005,400,000
Program in Aid of Irrigation .....	201,310,000
Program to Improve Drainage on Agricultural Lands .....	31,942,000
Program of Soil Surveys and Land Classification .....	28,620,000
Program of Research and Investigations .....	51,305,000
Program of Extension Education .....	60,074,000
A Supporting Credit Program .....	30,300,000
Rural Electrification (special studies only).....	138,000
30-Year Total	\$ 3,092,328,000

This is the estimated cost of thirty years of accelerated work to accomplish the comprehensive development of the Missouri Basin. It represents an expenditure of \$100,000,000 a year.

The Missouri Basin's improvement and development will yield many net gains in value far beyond the cost of the investment made by the public.

These benefits will appear in protected resources used to their full advantage on more productive farms, ranches, and forests and in substantial savings in flood damages. New service industries can be expected to come to the basin to provide the products a healthy and prosperous agriculture needs and buys. The list of benefits can be extended in many directions.

But, in its simplest meaning, the comprehensive development of the Missouri Basin is our guaranty that the people of the basin will have richer opportunities to live in security and happiness.

Secretary of Agriculture



SUMMARY OF ESTIMATES OF FEDERAL, STATE AND PRIVATE COSTS  
OF INSTALLING THE RECOMMENDED PROGRAM

Program	Costs to Federal Government	Costs to State and Local Governments	Costs to Land Owners and Operators	Total



MISSOURI RIVER

BASIN

AGRICULTURAL PROGRAM

A program for the development and conservation of land, water, and forest resources, and for flood control in the Missouri River Basin.

UNITED STATES DEPARTMENT OF AGRICULTURE

APRIL 1949





# MISSOURI RIVER BASIN AGRICULTURAL PROGRAM

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# MISSOURI RIVER BASIN AGRICULTURAL PROGRAM

## AUTHORITY

This report and the program set forth in it have been prepared under the provisions of various acts authorizing the Secretary of Agriculture to undertake investigations, surveys, research, and programs for the improvement of agriculture in the United States.

The following authorities, in particular, are the basis of the coordinated and cooperative effort which has produced the recommended program for the comprehensive agricultural development of the Missouri River Basin:

- ..." to conduct surveys, investigations and research relating to the conditions and factors affecting, and methods of accomplishing more effectively the .... promotion of the economic use and conservation of land ...." Act of February 29, 1936, as amended (16 U.S.C. 590i).
- ..." to cooperate with Federal, State, Territorial and other public agencies in developing plans for a program of land conservation and land utilization ...." Act of July 22, 1937 (7 U.S.C. 1011).
- ..." to cause preliminary examinations and surveys for runoff and waterflow retardation and soil erosion prevention on the watersheds of such localities ...." Act of June 22, 1936, as amended and supplemented (Public Law 738, 74th Congress).

Additional authority for this program planning is contained in the Act of May 15, 1862 (5 U.S.C. 511-514); the Act of April 27, 1935 (16 U.S.C. 590a); the Act of June 29, 1935 (7 U.S.C. 427); and the Act of May 20, 1936 (7 U.S.C. 902).

## PURPOSE

The program is directed toward improving and stabilizing agriculture in the Missouri Basin by the conservation, development, and use of the Basin's land, water, and forest resources. The recommended program will assist the people of the Basin to reach this objective. The ultimate purpose is to increase the economic and social well-being of the people of the Basin and in the Nation.

The recommended program is designed to:

- (1) Complement and protect flood control, irrigation, power, navigation, and other projects that have been authorized for the Missouri Basin. The recommended program is designed as an integral part of the coordinated Missouri Basin development and must be scheduled concurrently to achieve maximum benefits.
- (2) Protect, conserve, and improve the lands of the Basin for more efficient production and use by accelerating measures to conserve soil and moisture on farms, grazing lands, farm woodlots, and forests; the improvement and increase of timber, range, and wildlife resources; the enlargement of recreation opportunities; the planting and care of additional shelterbelts and extension of the shelterbelt area; the constructive rehabilitation of deteriorating lands and their conversion to better adapted uses; and the installation of other measures found necessary to contribute to productive and profitable land use.
- (3) Protect and enhance the water resource originating on the watersheds of the Basin, thus contributing to irrigation, navigation, power, domestic and industrial use; to fish and wildlife, and recreation; to pollution abatement; and to other productive uses.
- (4) Establish watershed practices and measures to aid in reducing flood and sediment damages, protect and effectuate large investments in water development structures, and safeguard farm lands, farm and urban property, railroads, and highways from flood and sediment damages.
- (5) Enlarge and improve the agricultural productive capacity of the Basin by irrigation and drainage wherever this will improve and stabilize incomes not only for farm people, but also for the communities of which they are a part.
- (6) Extend electricity, under a feasible loan program, to the remaining farms and rural non-farm areas without electric service.
- (7) Expand agricultural research, investigations, and surveys that are designed to give direction to resource development and use; solve problems arising from changes in land use; and discover production practices that will improve use of the soil and water resources and prevent their impairment.
- (8) Intensify the agricultural extension activities to assist rural people to make maximum use of lands newly developed for irrigation and protected from floods by levees and drains; to make the best use of electric power; to apply accelerated land conservation and flood reduction measures; and to adjust farming to new crops, new markets, and new methods.



## THE PLACE OF THE AGRICULTURAL PROGRAM IN COMPREHENSIVE MISSOURI BASIN DEVELOPMENT

The basin-wide agricultural program recommended in this report is designed to complement, support and protect the vast system of engineering works being constructed in the Missouri Basin under what has come to be known as the "Pick-Sloan Plan."

This plan was approved by the Congress in the Flood Control Act of 1944. It provides for the control of floods in the principal valleys of the basin, the irrigation of arid and semi-arid lands, the generation of power and the improvement of the river for navigation. Under the plan there are to be constructed 105 reservoirs capable of storing 100 million acre-feet of water, 1,500 miles of levees along the Missouri below Sioux City, and hydro-electric power plants with sufficient capacity to generate 10 billion kilowatt-hours of energy each year. The irrigation phase of the plan contemplates the development of 5 million acres of new irrigated land. In addition, it is planned to bring supplemental water to 2 million acres already under irrigation. Recreational facilities will also be provided.

The agricultural program is planned with full recognition of the fact that land and water programs are inter-related and inter-dependent. Taken together, therefore, these two programs comprise a comprehensive and unified approach to the full and efficient development, use and conservation of the two primary resources of the Missouri Basin - its lands and its waters.

The recommended agricultural program will reduce the rate at which major reservoirs fill with sediment. It will contribute to reduction of flood and related damages along the thousands of miles of tributary streams that will lie above these major reservoirs. It will assist in bringing into full and efficient use the new irrigated lands, help solve the drainage problems on lands behind the levees, extend aid to farm families who will be moving from reservoir areas, and in many other ways, complement and make more effective the engineering program. Improved and more stable incomes that result from more efficient use of land, water and forests will also make it possible for farmers to take fuller advantage of the opportunities provided by the engineering developments; in particular, it will enable them to utilize most efficiently the electrical power that is to become available and to repay the obligations incurred in expanded irrigation.

These are essential functions that the agricultural program will perform in the total development of the Missouri Basin resources in addition to the intrinsic worth of conservation and farm and forest improvements.

This report sets out a program designed to benefit all the farm families in the Basin and indirectly to benefit all farm communities and related business interests; a program which, with the Pick-Sloan Plan and the efforts of all the State governments and the people of the Basin, will provide for comprehensive development of the Missouri Basin.

### COOPERATION AND ACKNOWLEDGMENTS

The following agencies of the Department of Agriculture participated in the preparation of this program:

- Agricultural Research Administration
- Bureau of Agricultural Economics
- Extension Service
- Farm Credit Administration
- Farmers Home Administration
- Forest Service
- Production and Marketing Administration
- Rural Electrification Administration
- Soil Conservation Service

The field committee of representatives from the above agencies based the report on investigations and experience of agencies of the U.S. Department of Agriculture, the Land-Grant Colleges and Universities, the Great Plains Agricultural Council, and other agricultural agencies of the States in the Missouri Basin. The report has been prepared by the joint effort of agencies of the Department under the leadership of the Office of the Secretary, in cooperation with the States. Task committees of federal and State personnel prepared the various program recommendations. The estimates of conservation practices were made by federal representatives and were checked in each State. Cooperative aspects of the forestry program were discussed with forestry officials of the affected States. Both federal and State personnel participated in the program estimates for irrigation and drainage. The research program was prepared as one coordinated program by a technical committee of the ten Agricultural Experiment Stations and the research agencies of the U. S. Department of Agriculture with the additional cooperation of the Bureau of Reclamation. The same cooperative procedure was followed in planning the recommended soil survey program. The agricultural educational program was prepared by a committee established by the Agricultural Extension Directors of the Missouri Basin States, in cooperation with Federal Representatives. Information and assistance has been given by officials of the Department of the Army, the Department of the Interior, and various agencies of the Missouri Basin States in preparation of parts of this report.



## SECTION I

### GENERAL DESCRIPTION OF THE BASIN

#### PHYSICAL CHARACTERISTICS

##### LOCATION AND SIZE

The Missouri River Basin is a vast region extending from the forested Rocky Mountains of the Continental Divide, through the Great Plains to the humid areas of east-central Missouri. It includes all of Nebraska, most of South Dakota, large fractions of North Dakota, Montana, and Wyoming, about half of Kansas and Missouri, and smaller parts of Colorado, Iowa, and Minnesota. The part of the Missouri Basin lying in the United States covers about 326,000,000 acres, or 509,375 square miles. The part lying in the Provinces of Alberta and Saskatchewan, Canada, covers 9,715 square miles, or 6,217,600 acres. The proposed agricultural development program for the Missouri Basin embraces about 14,000,000 acres of land outside the Basin proper in North Dakota. This additional area is affected by the proposed diversion of water to the Souris and Sheyenne River basins. For purposes of this report, the term "Missouri Basin" includes all the Missouri River drainage, exclusive of the area in Canada, and the additional area in North Dakota. This is a total of approximately 340,000,000 acres.

##### PHYSICAL LAND CHARACTERISTICS

The Missouri River and its major tributaries rise in the Rocky Mountains of Montana, Wyoming, and Colorado, and flow in a generally easterly direction across the Great Plains. The main stem then flows south forming the boundary between Nebraska and Iowa and northern Kansas and Missouri. From Kansas City, the main river flows east to join the Mississippi near St. Louis. Minor tributaries rise in all the several States.

The eight major topographic conditions of the Missouri Basin are as follows:

1. Mountains
2. Rough land and badlands
3. Hilly land
4. Hilly to mountainous land

5. Moderately sloping land
6. Intermountain valleys
7. Hummocky (dune) land
8. Level land and undulating glacial drift

The topography and a general indication of rates of erosion in different parts of the region are indicated on Figure 1. Each of the eight topographic units has its own general characteristics of natural and accelerated erosion and therefore each is significant to the rate at which sediments are contributed to the Missouri River and its tributaries. The map and descriptive legend show where headward erosion of streams is rapidly reducing the surface of the land to a lower level and where natural and accelerated erosion is a serious hazard to agriculture, to forestry, to grazing, and to the permanency of proposed reservoirs of the Missouri River system. The descriptive legend also shows the principal kinds of rocks or other materials within each area, the general thickness of soils, and the present dominant land uses.

### Mountains

The only areas properly defined as mountains are in the western part of the region, chiefly the Rocky Mountains of Colorado, Wyoming, and Montana, and a small area in the Black Hills of western South Dakota. In these mountainous areas there are all kinds of rocks, and the thickness of soil varies from nothing to many feet. Natural erosion in the mountains is slow in most places, but is rapid where soft rocks are exposed. Geologic erosion in these areas is actually fairly rapid, but the annual load of sediment contributed to the streams is not excessive. Much of the excess sediment is carried down from steeper slopes and lodged in intermountain valleys and does not contribute a great deal to downstream areas. Accelerated erosion occurs in the mountains when the forest cover has been badly depleted or destroyed. In these cases steep topography can create a serious problem. The mountain areas are used chiefly for timber, grazing, sources of water supplies, wildlife habitat, and recreational purposes.

### Rough Lands and Badlands

In the region between the Rocky Mountains and the eastern part of the Great Plains and in the larger of the intermountain basins of Wyoming are to be found the rough land and badlands of the Basin. These are vast areas of rather high land where bedrocks are largely of siltstone, soft shale, clay, and soft and hard sandstones. Most of the rocks are soft and easily attacked by natural erosion. A large proportion of the rough land of this region has either a semiarid or an arid climate and natural vegetation is relatively thin and incapable of protecting the land from erosion. Headward erosion by tributaries of the Missouri is extremely active, and an enormous amount of sediment is carried into the mainstream. Soils in the rough lands and badlands are generally shallow, though there are many local exceptions where soils are deep enough to be suitable for dry farming, irrigation, and





## DESCRIPTIVE LEGEND

### PHYSICAL LAND CHARACTERISTICS OF THE MISSOURI BASIN









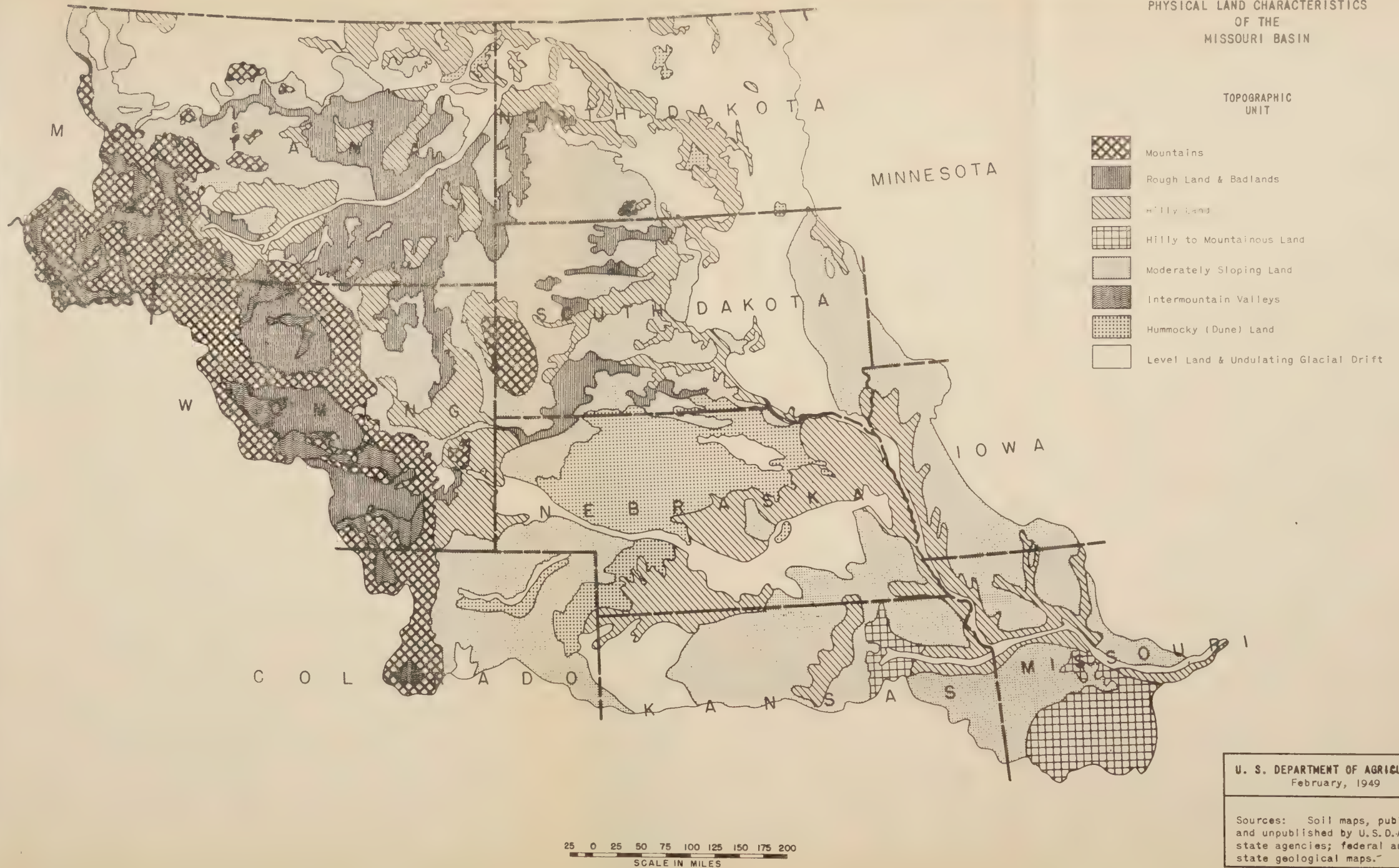
Symbol	Topographic Unit	Rock or other Materials	Soil Depth	Natural Erosion	Accelerated Erosion	Dominant Uses
	Mountains	All kinds of rocks	Bare rock to deep soils	Slow to Rapid	Lacking to moderate	Forestry, grazing, water conservancy & recreation
	Rough Land & Badlands	Siltstone, shale, clay, & sandstone (mostly soft)	Generally shallow	Rapid to extremely rapid	Slow to moderate	Largely for grazing
	Hilly Land	Soft rocks, glacial till, loess, & a few hard rocks	Shallow to very deep	Rapid to moderate	Generally slow where grazed; very rapid where cultivated	Largely grazing; cultivation important in subhumid areas
	Hilly to Mountainous Land	Chiefly limestone & flint (chert)	Shallow to deep, mostly stony soils	Slow to moderate	Slow to rapid	Forestry, grazing, general farming, fruit
	Moderately Sloping Land	Soft rocks, glacial till, loess, & a few hard rocks	Moderately deep to very deep	Slow to very slow	Moderate to rapid	Largely cultivated; grazing important in semiarid regions
	Intermountain Valleys	Silty, clayey, & sandy materials	Generally deep	None to moderate	None to rapid	Irrigation & dry farming; grazing
	Hummocky (Dune) Land	Sand	Thin soil over deep loose sand	Slow to very slow	Generally very slow; extremely rapid wind erosion if plowed	Grazing
	Level Land & Undulating Glacial Drift	Glacial till, alluvium, & loess	Generally deep to very deep	Very slow	Generally slow to moderate according to slope. Moderate wind erosion.	Generally cultivated where moisture is adequate; irrigation farming important



Figure 1  
PHYSICAL LAND CHARACTERISTICS  
OF THE  
MISSOURI BASIN







good grazing. Natural erosion is rapid to very rapid and was so even before the region was first explored by white men. As very little of this land has been brought under cultivation, accelerated erosion is rapid only where ranchers have attempted to graze more livestock than the thin vegetation can support. Nearly all of the rough lands and badlands are used for grazing. Within the areas are many small strips of deep alluvial soils and of fertile soils of stream terraces and narrow ridge tops that are suitable for either irrigation or dry farming. These localities cannot be designated on a map of the scale of Figure 1.

### Hilly Lands

The hilly lands of the Missouri Basin extend intermittently all the way from the bluffs of the Missouri River in eastern Missouri to the foothills of the Rocky Mountains. A small-scale map cannot show sharp distinctions between the hilly lands and the rough broken lands on the one hand and the moderately sloping lands on the other. Most of the hilly lands are of soft rocks, like the Pierre shale and the Hell Creek and Fort Union beds; or glacial till largely of clay loam texture; or loess like that of Nebraska, Kansas, Missouri, and Iowa. Smaller areas, especially near the western mountains, have many outcrops of hard rock. Soils on the hills vary from shallow to deep. Most of them are capable of supporting a good natural growth of grasses, as in the central and western parts of the Basin, or of trees, as in the eastern part of the Basin in Iowa and Missouri. Hence, the rate of natural erosion on these areas is considerably less than it is on the rough lands and badlands, and the contribution of silt under natural conditions is much less. However, the soils of much of the hilly land, especially those in Nebraska, Kansas, Iowa, and Missouri, are physically suitable for cultivation and the rate of accelerated erosion has become very rapid where such lands are cultivated. Where the original cover of grass or forest has been allowed to remain, the rate of accelerated erosion is slow except where the cover has been depleted or destroyed by heavy timber cutting, overgrazing, and fire. Much of the hilly land is used for grazing, but substantial areas in eastern Nebraska and in western Iowa and Missouri are used for clean-tilled crops. These cultivated areas have contributed an enormous amount of sediment, especially to the main stream of the Missouri River, and the Platte and Republican Rivers, as well as to streams in northern Missouri.

### Hilly to Mountainous Lands

In the wooded Ozark Highlands in Missouri, south of the Missouri River, and the grassy Flint Hills of northeastern Kansas are to be found the hilly to mountainous land of the Basin. These lands are rougher than the "hilly lands," and the parent materials are largely hard bedrocks instead of soft rocks, loess, and glacial till. The soil varies from very shallow to quite deep, and a fairly large proportion is so stony that cultivation is either difficult or impossible. Natural erosion is slow to moderate, and nowhere does it contribute a large

amount of sediment to streams. Accelerated erosion, on the other hand, varies a great deal according to land use. Ordinarily the accelerated erosion is slow, but it is fairly rapid where the land has been deforested or overgrazed. Chief uses of hilly to mountainous land are for timber production, grazing, and wildlife habitat. General farming and fruit growing occur in the more favored locations.

### Moderately Sloping Lands

By far the greater part of the moderately sloping land of the Missouri Basin is in areas of various kinds of soft rocks, glacial till, and loess. Interspersed with the soft rocks are a few reaches of hard rocks, chiefly with linear outcrops. Soils in general range from moderately deep to very deep with a small proportion of shallow soils and rock outcrop. Under virgin conditions, most of these areas supported a good natural vegetation of tall grasses in the eastern part of the region and of short grasses in the drier western parts. Erosion was slow to very slow at the time the land was first explored. Since the land has come under white settlement, however, a large proportion of these moderately sloping lands has been brought under cultivation, and accelerated erosion is moderate to rapid. These areas now contribute much sediment to the streams. A large share of the land is used for cultivated crops, especially in the subhumid central and eastern parts of the Basin. Farther west, where the climate is semiarid, grazing is the predominant use although there is some dry farming. Many gullies have worked back into the moderately sloping land from hilly areas near the larger streams.

This class includes only those parts of the moderately sloping lands of the Missouri Basin with a well-defined natural drainage system connected directly to the major streams. Those moderately sloping areas that do not contribute much water directly to the major streams are included in "level land and undulating glacial drift."

### Intermountain Valleys

Intermountain valleys are the chief farm areas within the Rocky Mountains. Most of these valleys are filled with silty, clayey, or sandy sediments that have accumulated more rapidly than the streams were able to remove them toward the sea. From these sediments, moderately deep to deep soils of many different kinds have been formed. Natural erosion varies from a negligible rate to rather rapid. The most rapid natural erosion is in areas of soft deposits that have been subjected to the attack of streams through the deepening of valleys and headward erosion by the streams. Accelerated erosion is negligible in many of the intermountain valleys, but, it is at moderate rates in sloping areas that have been brought under cultivation without proper erosion control practices. The most important uses are for irrigation farming, dry farming, and the production of native hay. Some of the most important irrigation districts of the West are in these valleys. Land that is unsuitable for irrigation and dry farming is generally used for grazing.



### Hummocky (Dune) Lands

The hummocky (dune) lands of the Missouri Basin include the enormous Sandhill area of Nebraska and similar smaller areas in other States. This land consists of hummocky reaches of loose dune sand. Nearly all of it has been stabilized by natural vegetation and thousands of small basins, some of which are semi-marshy, some of which are dry, and some of which contain small lakes. Soils in these deep sands generally are rather thin, although the loose sand deposits themselves are thick. Under natural conditions, erosion is very slow. A great deal of sand is carried by the streams, however, and clogs diversion and power dams. Accelerated erosion, almost entirely by wind action, is generally confined to small patches of "blow outs" where vegetation has been killed by imprudent plowing or by excessive trampling by livestock. The basins between the sand dunes are moist enough in many places to be used as natural meadows from which hay is harvested for winter feed for livestock. The present and best use of practically all this land is for grazing. The sandy soils absorb most of the rainfall which recharges ground water and stabilizes stream flow.

### Level Land and Undulating Glacial Drift

This land is underlain by alluvium, loess, and glacial drift of greatly varying character. Soils are generally deep to very deep, and natural erosion is slow to very slow. Wind is the chief agency of accelerated erosion on the level areas. Wind erosion has been rather severe on cultivated land during droughty periods, especially on very sandy and very clayey soils. Accelerated water erosion is active on the higher spots of the undulating glacial drift, but the soils washed from the knolls usually collect in intervening basins and do not contribute much sediment to the major streams. Most of the land of this unit is used for cultivation where the moisture supply is adequate. Some of the most important areas of irrigated farming are on this class of land in the semiarid parts of the basin.

## MAJOR PARENT MATERIALS AND SOIL ZONES

### The Parent Materials

Many kinds of rock occur within the Missouri Basin, and each kind of rock has its distinctive effects on the kinds of soil developed from it. The major parent materials of soils of the Basin, including soft mineral deposits, fall into four major groups, as follows (fig. 2):

1. Very sandy deposits, many with dune forms
2. Clay and silty clay or clay-shale rocks
3. Soft medium-textured rocks, loess, glacial till, and alluvium
4. Chiefly hard rocks

The very sandy deposits, like those of the Sandhills of Nebraska, are loose and easily eroded by wind. The soils on them can be used only for grazing. Under this use, they will sustain a healthy and prosperous livestock industry for an indefinitely long period.

The soils developed from clay deposits and silty clay or clay shales generally are too heavy and too vulnerable to erosion damage for high agricultural production. But they will support a fair to good grass cover for grazing.

Soils developed from soft rocks, loess, glacial till, and alluvium, generally are fairly well to very well suited to the type of farming that fits the climate of the area. The great wheat and corn areas of the Missouri Basin are largely on these materials.

In areas dominated by hard rocks, such as the Rocky Mountains, the Black Hills, the Ozark Highlands, and the Flint Hills of Kansas, the soils are generally best suited to forestry or grazing. A large proportion of them—perhaps half, more or less—are too stony or too shallow for easy cultivation. Much of the area in which hard rocks are dominant is in the Rocky Mountains where short growing seasons make forestry and grazing the most practical land uses.

### The Soil Zones

The natural soil zones of the Missouri Basin are related closely to the zones of climate and natural vegetation. In their broad distribution the soils owe many of their important and easily recognized characteristics to the climate and vegetation under which they have developed.

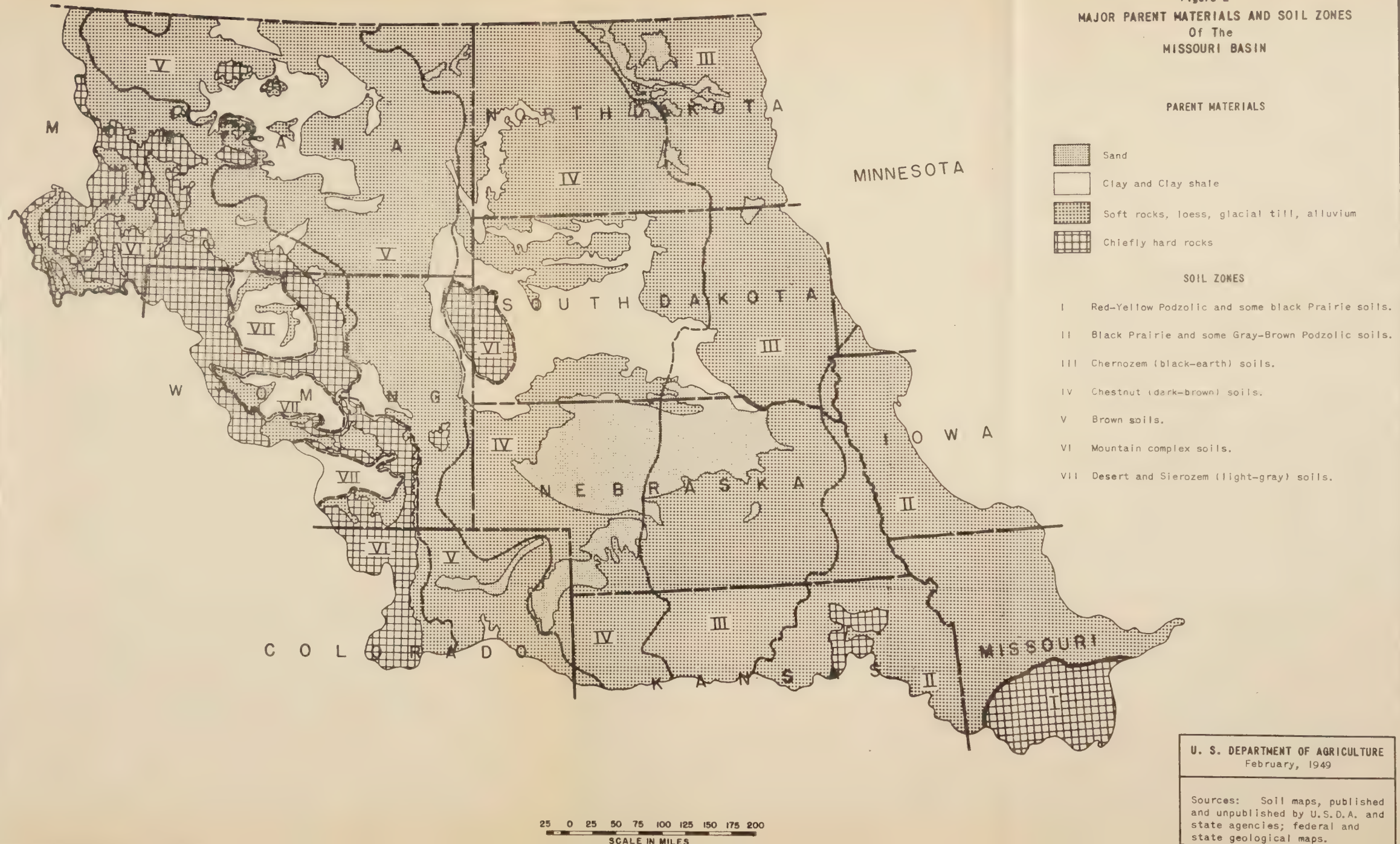
Superimposed on the maps of parent materials and natural vegetation (figs. 2 and 3) are some dashed boundary lines to separate the major soil zones. The soil zones are indicated on the maps by Roman numerals from I to VII, progressing from the humid parts of Missouri to the arid intermountain basins of Wyoming.

Zone I includes the area of acid pale-colored soils with red or yellow subsoils (Red-Yellow Podzolic soils) that occur in southern Missouri. In Missouri, a great many of these soils are too stony for farming and are used for forest and pasture. Most farming is of a general type and cultivation is chiefly along the stream valleys and smoother ridge tops. Most red and yellow soils of this zone require lime and fertilizers.

Zone II includes areas of slightly to moderately acid black Prairie soils with many important local variations that correspond with the character of parent material and age of the soil. Most of this area is in the Corn Belt. Within Zone II are many small and a few large areas of acid, light-colored, Gray-Brown Podzolic soils that have developed under hardwood forest, especially in northeastern Missouri.



Figure 2  
MAJOR PARENT MATERIALS AND SOIL ZONES  
Of The  
MISSOURI BASIN



U. S. DEPARTMENT OF AGRICULTURE  
February, 1949

Sources: Soil maps, published and unpublished by U.S.D.A. and state agencies; federal and state geological maps.





Zone III is the famous Chernozem (Black-Earth) belt of the northern plains. Soils in this area are very dark-colored and generally slightly acid to neutral in reaction. The major differences between Chernozem and the black Prairie soils are that the former are usually less acid and have a layer of lime-carbonate concentration 1 to 5 feet below the surface. True Chernozems are deep, highly fertile soils, but their productivity is limited during many years by lack of sufficient moisture. The Corn Belt extends well into the Chernozem soils zone.

Zone IV is the area of Chestnut (Dark-Brown) soils that are developed under a somewhat drier climate than are the Chernozems. Most Chestnut soils are highly fertile, but they occur under climates that are generally too dry to be reliable for corn; hence, their chief use is in winter or spring wheat production, much of it under alternating fallow and crop.

Zone V includes the vast area of Brown soils of the semiarid short-grass plains. These soils are lighter colored and lower in organic matter than the Chestnut soils, but most of them are fertile. Crop production, chiefly wheat, is sharply limited by climatic conditions, but yields are high in favorable years. Dry fallow farming for moisture conservation and strip cropping to check wind erosion are widely practiced.

Zone VI includes a vast area of mountains in the western part of the Basin, where soils are extremely variable in character. The major soil characteristics vary, with the local climate and vegetation, from Prairie and Gray-Brown Podzolic soils much like those of north-central Missouri to Desert soils like those of the desert basins in Wyoming. Probably at least half of the soils of Zone VI are shallow and stony.

Zone VII includes the very light colored Desert and light gray Sierozem soils of the deserts and semideserts, confined almost entirely to Wyoming. Most of these soils are rich in mineral plant nutrients, but very low in organic matter and nitrogen. Many areas have been made productive by irrigation, accompanied by drainage. In this zone there is a constant hazard of salt accumulation in irrigated soils that are not artificially drained.

#### Local Variations in Soils

While the zonal differences of soils are significant, local differences in soils within each of the great soil zones are of very great importance. These differences, which limit the adaptability of crops and the size of yields are due (1) to differences in parent materials; (2) to the effects of soluble salts in the soil; (3) to the age of the soil; (4) to the natural drainage (or lack of it); (5) to differences in natural vegetation; (6) to the use or abuse of the soil since it has been cultivated or put to other use; and (7) to slope of the land.

The black Prairie soil of eastern Nebraska ordinarily is expected to yield a larger income per acre than a Brown soil of eastern Colorado. But favorable local soil conditions in the Brown soils zone and unfavorable local soil conditions in the Prairie zone can reverse this result.

### Salts and Alkali

A considerable portion of the land to which water might be made available for irrigation would prove to be unsuitable for irrigation because of the presence of salts or the possibility that the accumulation of salts and alkali under irrigation would make the areas too toxic for plant production.

Even in areas where no salt or alkali problems now exist under dry farming, salts known to be present in the lower horizons of the soil profile may create a salt or alkali problem when irrigation systems are installed. The irrigation waters become impregnated with salt or alkali and percolate downward until a less permeable layer is encountered. This layer may be of such a fine texture or density that it is only slowly permeable and causes what is called a "perched water table" to develop above it. Elsewhere, the irrigation water may percolate downward until it reaches a relatively impermeable layer of shale or some other material. In either instance, the water collects above and moves along the surface of the less permeable layers and tends to become ponded in basin-like areas caused by the uneven surface of the less permeable layer. A water table is created which may actually reach the surface where the less permeable layer outcrops. When this water evaporates, the salts contained in it are left behind to become concentrated locally in quantities large enough to damage soil structure and to harm or prohibit plant growth.

Most of the irrigable areas on stream terraces and bottoms throughout the Missouri Basin area have problems of salt or alkali, and drainage, that must be studied together. Even in areas where salts are not in sufficient amounts to be harmful under dry farming, soil surveys should be made to learn whether there are any underlying, less permeable layers, which, under irrigation, would not drain or would act as a floor for water movement and cause the described conditions to develop. Where studies indicate the possibility that harmful water movement or accumulation may occur it may be possible to establish remedial drainage measures.

Even on dry farm and range land there are many large areas where salt and alkali accumulations limit production to some extent.

Local conditions--like texture or parent material, content of soluble salts, depth and structure of soils, and adaptability of soils and underlying materials to artificial drainage--are among the considerations that are important to the classification of soils for irrigation. These and other soil characteristics, locally significant



to all kinds of intensive land use and soil conservation and rehabilitation practices, can only be determined by detailed soil surveys and field investigation.

### NATURAL VEGETATION

The Northern Great Plains, a vast natural grassland area, lies between the Rocky Mountains and the humid forested areas of Minnesota, Iowa, and Missouri. (fig. 3). In general, the type of grass or other vegetation has been determined by regional and local environment. Climate, soil, relief, and drainage are the important factors. Forests predominate in the humid southeastern parts of the Basin and the mountainous areas, sagebrush in semidesert areas, greasewood on salty soils in the dry parts of Wyoming and Montana, and grasses over the rest of the region. In the western mountains, the forests consist mostly of ponderosa pine, lodgepole pine, Douglas fir, Alpine fir, and Engelmann spruce. The Ozark Highlands are characterized by several species of oak, hickory, ash, and black walnut.

In the eastern, more moist part of the grasslands, the dominant species are tall grasses (bluestem, needlegrass, wheatgrass, and sand grass); farther west short grasses (grama grass and buffalo grass) dominate the vegetal cover. The boundary between the short-grass and tall-grass areas is not sharp. Rather, there is a broad belt in which both tall and short species grow and the dominance, if any, is determined by local conditions of soil, relief, and drainage.

A noteworthy feature of these grassy plains is the presence of trees along streams, on some north-facing slopes, and in other places where soil moisture is greater than on uplands. These trees are chiefly broadleaf species, such as cottonwood, willow, white elm, ash, and bur oak. Red cedar and ponderosa pine are fairly common on some of the steep slopes along streams in the plains.

### CLIMATES OF THE MISSOURI RIVER BASIN

#### General

Farmers in the Missouri River Basin must adapt their operations to extreme variations in weather. Unreliability of rainfall and extreme temperatures are the two things in particular that cause trouble.

The climates of this region are continental. They are characterized by extremes and great irregularity throughout the four distinct seasons of the year. Winters are relatively long and cold over much of the Basin while summers are sunny and hot. Spring is cool, moist, and windy and autumn is cool, dry, and sunny. Other climatic factors important to farmers in the Great Plains of the Basin are low humidity, much wind, excess of evaporation over precipitation, and a great deal of sunshine.

If the climates were uniformly arid, semiarid, or humid, the farmer could easily select suitable types of farming, crops, and practices and calculate with some accuracy his chances of success. However, in most of the Basin, years with better-than-average weather—sometimes several in succession—encourage farmers to grow crops and use practices suited to more humid regions. Then crop and livestock losses are heavy when unfavorable weather conditions come.

The dominant climatic divisions run roughly north and south in the Basin. (fig. 4) The Southeastern part is humid and has a relatively long growing season. Here climatic conditions constitute the least hazard to agricultural production. The rest of the eastern half has a subhumid climate, with greater farming risks. The western part is still drier and cooler and has a shorter growing season, making agricultural production more difficult and hazardous. In the high mountains on the western edge of the Basin the climate is again humid. Rainfall in the mountains is the source of most of the water for irrigation and other uses in the western plains.

Most of the Basin has the level, undulating, and rolling landscape of the plains, but the hills and mountains are large enough in some places to cause local differences in climate. The Black Hills of South Dakota, surrounded by semiarid grasslands, are humid and forested. The Big Horn Mountains of Wyoming and smaller groups of mountains in Montana, form other humid "islands" in the midst of a dry zone. Lesser local variations of weather and climate are caused by hills, bluffs, escarpments, and deep valleys. These variations take the form of lower or higher average temperatures, greater or lesser wind speeds, or greater or less precipitation than in surrounding country.

The map (fig. 4) shows the distribution of normal climates in the Basin; that is, the climatic distribution based on mean temperature and precipitation gained from years of observations. However, variability characterizes all climates and especially those of continental types. The two following maps (figs. 5 and 6) indicate the percentage of years in which the various parts of the Basin have, respectively, arid and humid climates, and thus give some measure of the variability.

#### Temperature, Frost and the Frost-Free Season

Continental interiors, like the Missouri Basin, are noted for extremes of temperature as a result of their distance from large bodies of water which are slow to warm and cool. The Basin is, moreover, influenced alternately by air masses from cold northern regions and from tropical lands and waters. Therefore, the seasonal variation and daily range in temperature is great, and violent temperature changes sometimes occur within a few hours.

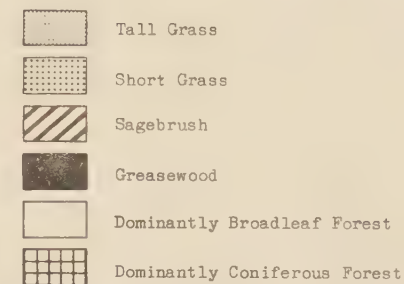
Average annual temperatures in the Basin range from about 55° F. in the southeast to less than 40° F. in the northwest. In most places the highest temperature recorded is at least as high as 110° F. and the



Figure 3

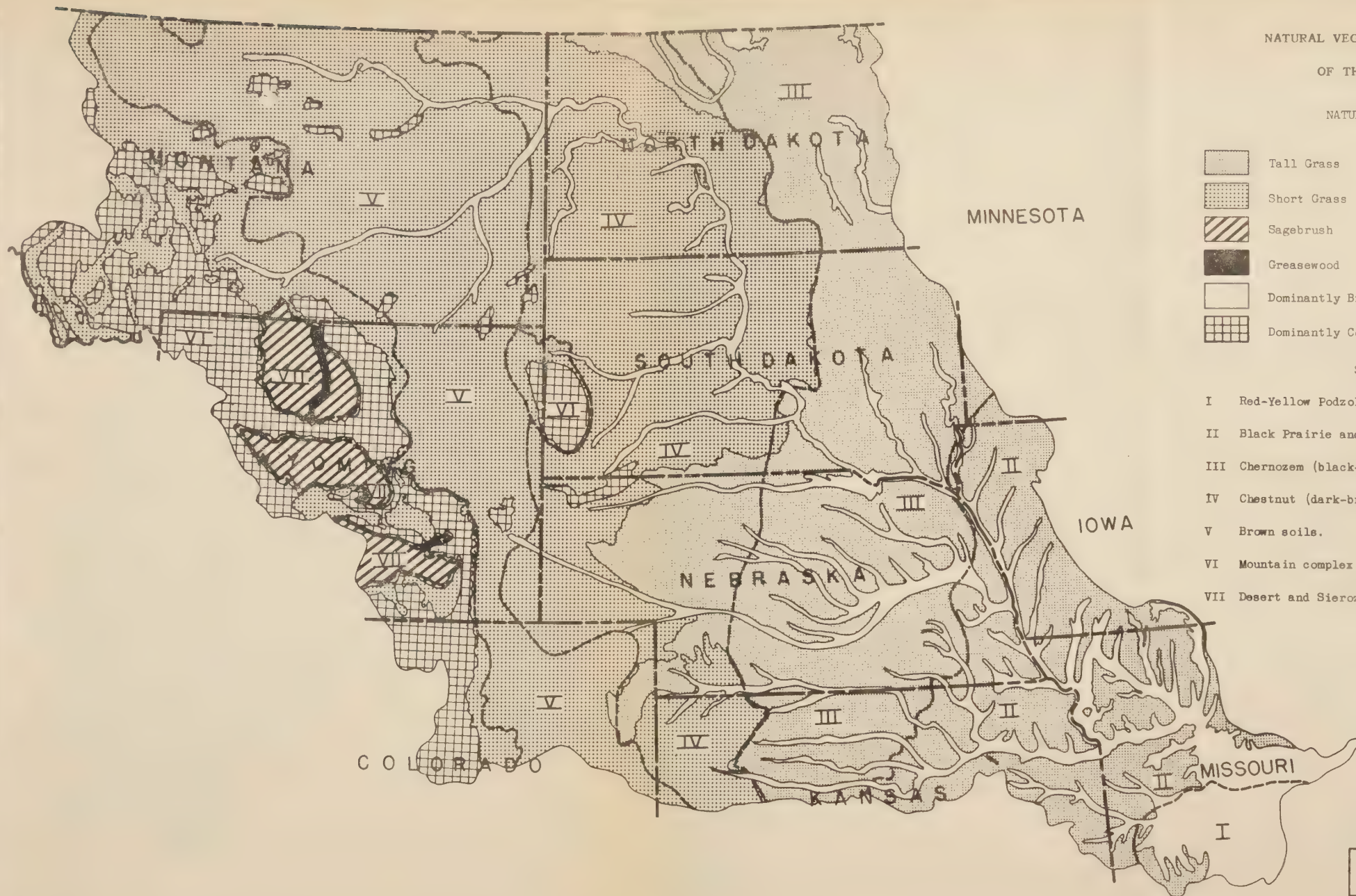
# NATURAL VEGETATION and SOIL ZONES OF THE MISSOURI BASIN

## NATURAL VEGETATION



## SOIL ZONES

- I Red-Yellow Podzolic and some black Prairie Soils.
- II Black Prairie and some Gray-Brown Podzolic soils.
- III Chernozem (black-earth) soils.
- IV Chestnut (dark-brown) soils.
- V Brown soils.
- VI Mountain complex soils.
- VII Desert and Sierozem (light-gray) soils.



25 0 25 50 75 100 125 150 175 200  
SCALE IN MILES

U. S. DEPARTMENT OF AGRICULTURE  
February, 1949

Sources: Soil maps, published and unpublished by U.S.D.A. and state agencies; federal and state geological maps.





# NORMAL CLIMATES, MISSOURI RIVER BASIN

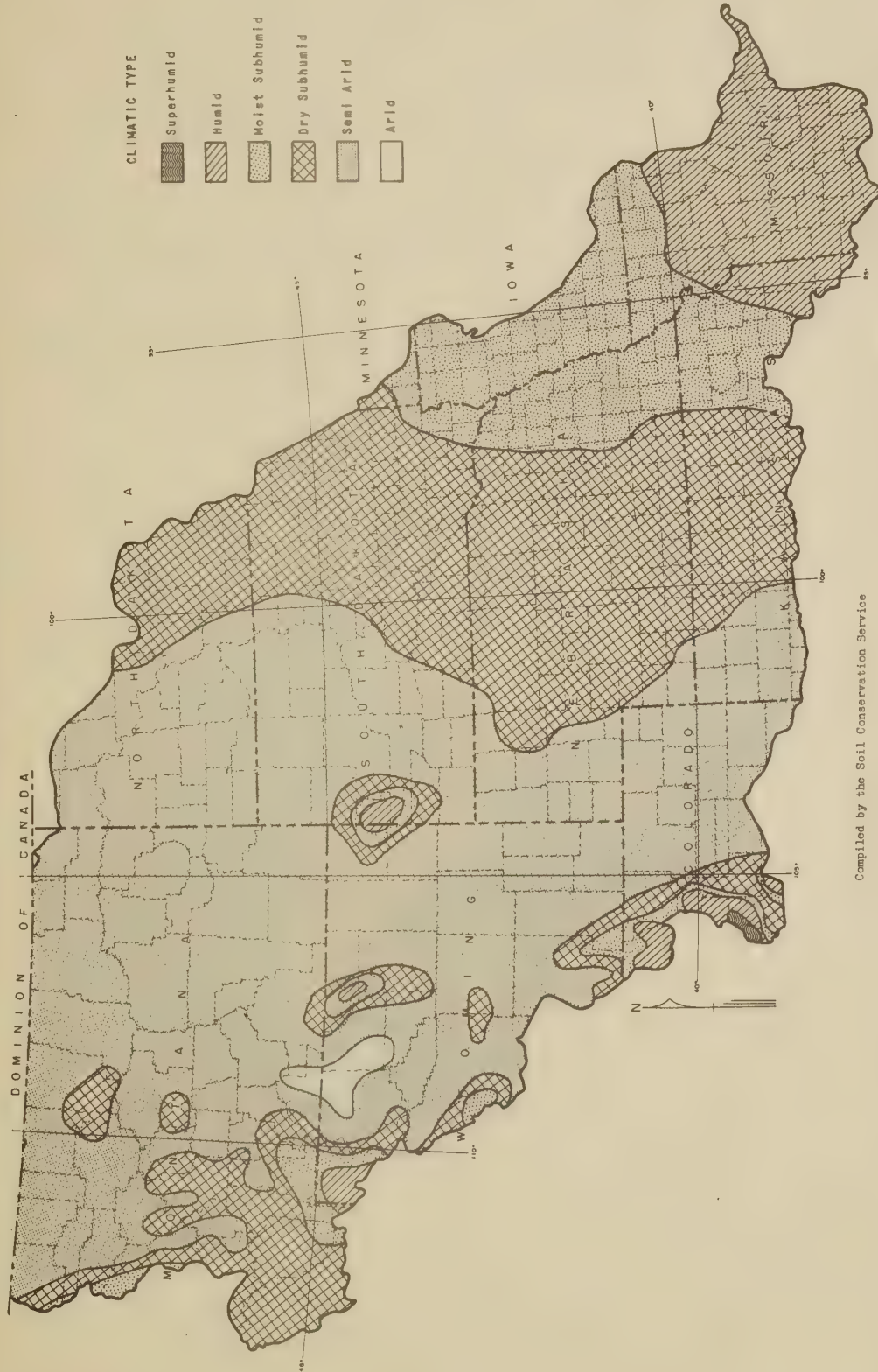


Figure 4.- The normal climate of the eastern part of the Basin is humid and the western part, except for the mountains, is semi-arid.





# FREQUENCY OF ARID CLIMATE, MISSOURI RIVER BASIN

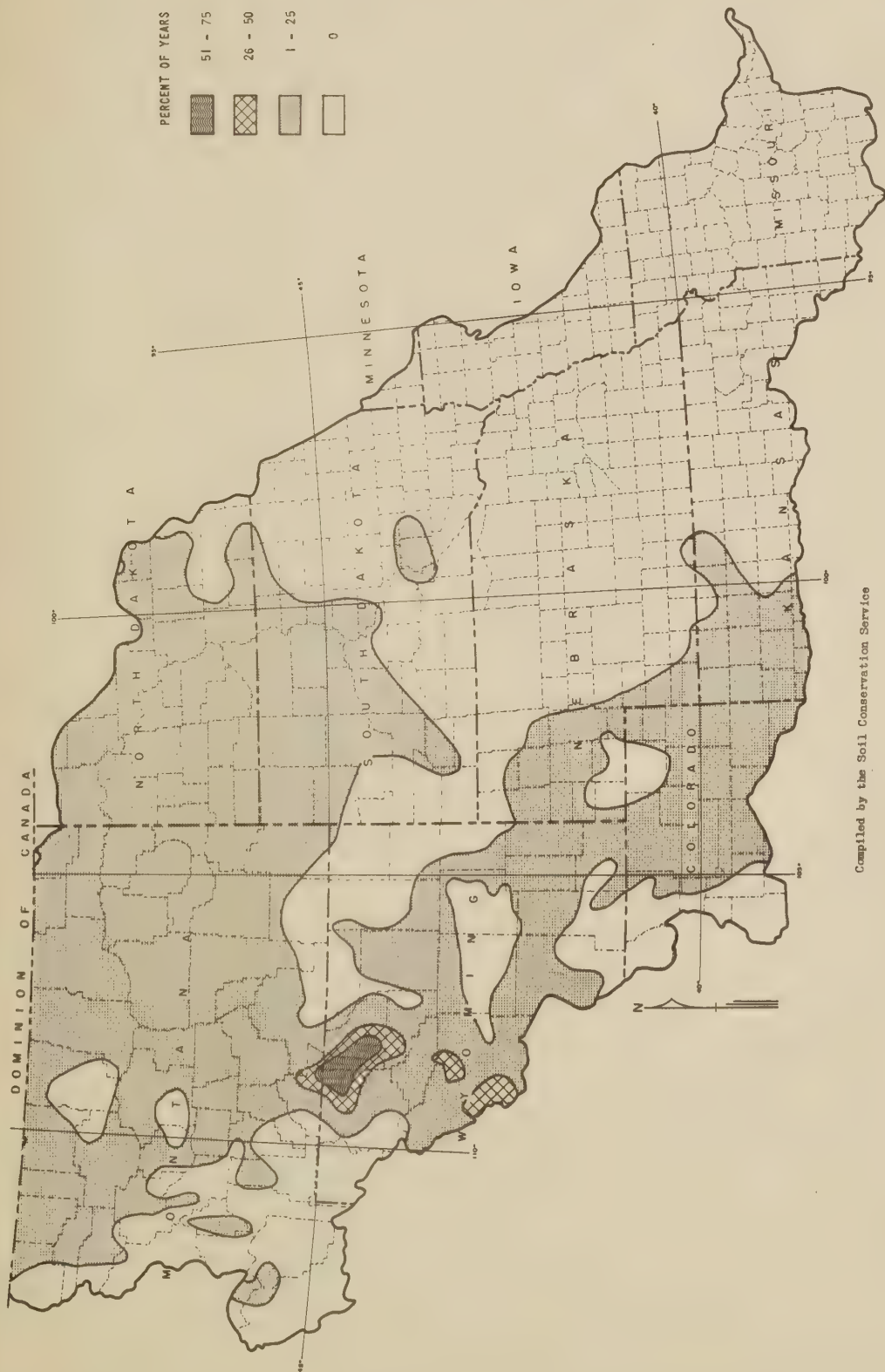


Figure 5.- In some years a large portion of the Basin has an arid climate.





# FREQUENCY OF HUMID CLIMATE, MISSOURI RIVER BASIN



Figure 6.- In some years a large portion of the Basin has a humid climate.





lowest at least as low as  $-20^{\circ}$  F. Extremes are beyond these limits in certain areas.

The earth freezes every winter in the Basin, but it may not remain continuously frozen everywhere. In the southern part and in some places along the eastern slopes of the Rocky Mountains, the ground usually freezes and thaws a great many times each winter.

The map (fig. 7) shows the average length of the frost-free season, frequently called the growing season, in the Basin and the average minimum and maximum monthly temperatures at selected stations.

### Wind

The Great Plains part of the Missouri River Basin is noted for windy weather. Winter winds are predominantly from the northwest and west, while summer winds come mostly from a southerly direction.

The highest average annual wind speeds are about 13 miles an hour and occur in the northeastern part of the Basin. The greatest wind speeds recorded vary from about 45 to 70 miles an hour, depending on the locality. Strong winds are most frequent in March, April, and May. High winds and high temperatures result in high evaporation, and dust storms result when vegetation is sparse.

Blizzards characterize the winter of nearly all parts of the Basin. The blizzard is a strong wind, usually northwesterly, accompanied by low temperatures, a variable but generally low snowfall, and drifting snow. Blizzards frequently cause great hardship, loss of property, and even loss of life.

### Evaporation and Transpiration

In all parts of the Basin, the potential evaporation and transpiration are greater than the precipitation. Actual evaporation is less than precipitation only because part of the water is absorbed and held by the soil and part is lost by runoff. For these reasons moisture conservation practices which decrease runoff and increase absorption by the soil are extremely important.

Climatic data for the Basin include little information on the loss of water by evaporation from the soil and transpiration by plants. But evaporation from free water surfaces, such as lakes and streams, is highest in the area of lowest relative humidity in the southwestern part and lowest in the humid northeastern part. However, the combined evaporation from soil and transpiration from plants is highest in the region of highest rainfall in the southeast and decreases progressively toward the northwest.

Losses by evaporation from a free water surface vary from about 20 to 40 inches a year, while evaporation from soil plus transpiration ranges from about 10 to about 30 inches a year.

## Precipitation

Autumn, winter, and spring precipitation in the Missouri River Basin is generally "frontal" or "cyclonic storm" precipitation. This kind of precipitation, much of which comes as snow, falls at a slow rate and over relatively long periods. Individual storms cover areas as great as 100,000 square miles.

Summer precipitation is mostly rain of the thunderstorm or convectional type. These rains generally cover small areas although scattered storms may affect a relatively large area on any given day. The rain usually comes in the form of short hard showers which are sometimes accompanied by hail and strong winds. The great disadvantage of this type of rainfall is that so much of it is lost by runoff instead of soaking into the soil.

In some places, notably the Black Hills of South Dakota and the Big Horn Mountains of Wyoming, a third type (orographic) results in total precipitation that is markedly higher than that of the surrounding lands.

The heaviest rainfall comes when it is most needed for crops and pasture—in May, June, and July (fig. 8). Unfortunately, much of the rain in these months comes from torrential thunderstorms, and loss by runoff is high.

The above data do not indicate the irregularity and unreliability of rainfall from year to year. In areas where average rainfall approaches the minimum for crop production, this irregularity becomes extremely serious. Less than average rainfall in these areas means crop failure or severe reductions in yields.

## Rainfall Intensities

The highest rainfall intensities occur in the southeastern part of the Basin. Even in the desert areas, however, cloudbursts occur from time to time in which an amount of water equivalent to a large part of the average annual precipitation may fall within a few hours. Most of this water rushes off in streams and may carry with it considerable sediment. The greatest number of very intense rainfalls occur in May, June, and July, associated with thunderstorms.

The maps (fig. 9 and 10) show the maximum 24 hour rainfall that may be expected once in 10 years and once in 50 years, on the average.

## Snowfall

The average annual snowfall varies from about 20 inches in the southeast to about 200 inches in the western mountains. Although the snow cover usually is not continuous through the winter except in some parts of the mountains, and though much water is lost by evaporation, snow is an important source of soil moisture and sometimes contributes to spring floods. Snow in the mountains is the chief source of water for irrigation.





Figure 7

AVERAGE ANNUAL GROWING SEASON  
IN DAYS WITH EXTREME AND  
AVERAGE TEMPERATURES FOR  
SELECTED STATIONS

Compiled by the  
Soil Conservation Service







Figure 8

AVERAGE ANNUAL RAINFALL WITH  
AVERAGE AND EXTREME MONTHLY  
VALUES FOR SELECTED STATIONS





[illegible]

Figure 9.- The most intense rainfall occurs in the southeastern part of the Basin.

Figure 9.- The most intense rainfall occurs in the southeastern part of the Basin.





# 24 HOUR RAINFALL IN INCHES 50 YR. FREQUENCY, MISSOURI RIVER BASIN

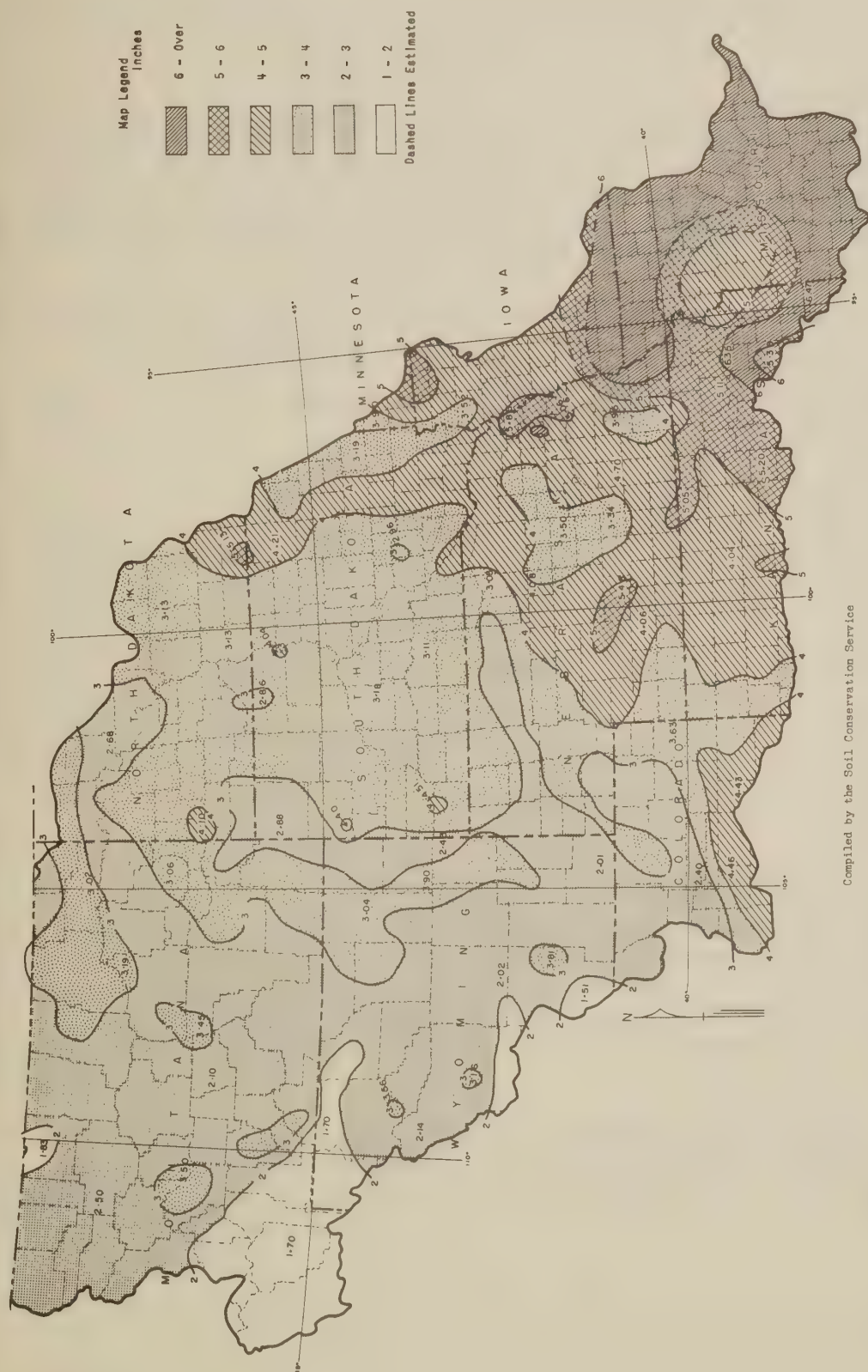


Figure 10.- Most of the Basin is subject to intense rainfall from time to time.





ECONOMIC DEVELOPMENT

IMPORTANCE OF MISSOURI BASIN AGRICULTURE IN THE NATIONAL ECONOMY

Agriculture in the Missouri River Basin represents an important part of the national economy. The Basin area of approximately 340 million acres is about 18 percent of the land area of the United States. About one-fourth of the Nation's farm land and the same proportion of the harvested cropland is within the Basin. In contrast, this land is operated by one-tenth of the Nation's farmers (table 1).

Table 1.—Comparison of Agricultural Statistics for the United States and the Missouri River Basin

Unit	:	Unit	:	United States	:	Missouri Basin	:	Percent of United States Total
Land area	:	Million acres	:	1,905	:	340	:	17.8
Land in farms	:	Million acres	:	1,142	:	282	:	24.6
Cropland harvested	:	Million acres	:	353	:	91	:	25.8
Number of farms	:	Thousand	:	5,859	:	582	:	9.9
Farm population	:	Thousand people	:	23,558	:	2,096	:	8.9
Value of land and buildings	:	Million dollars	:	46,389	:	6,557	:	14.1
Value of farm implements	:	Million dollars	:	5,147	:	847	:	16.4
Value of livestock	:	Million dollars	:	8,472	:	1,663	:	17.2

Source: 1945 Census of Agriculture

Capital values in agriculture in the area represented an investment of about 9 billion dollars in 1945. The value of land and buildings accounted for 6.6 billion dollars of this total. Farmers sold 2.7 billion dollars' worth of products in 1944. This is the sum of 1.6 billion in livestock sales, 900 million from the sale of crops, 1.3 million from forest products, and 200 million in products used in the farm home.

Sales of live animals, wool, and meat amounted to 1.2 billion dollars and were the major source of income in comparison with 185 million dollars from dairy products and 197 million dollars from poultry and poultry products (table 2).

Table 2.—Value of Livestock and Livestock Products Sold, 1944,  
Missouri River Basin

Commodity	United States	Missouri River Basin	Percent of United States Total
	Million Dollars	Million Dollars	Percent
Live animals, wool, meat, etc.	4,527	1,220	27
Dairy products	2,531	185	7
Poultry and poultry products	1,587	197	12
All livestock and livestock products sold	8,645	1,602	19

Source: 1945 Census of Agriculture

More than half of the crops produced in the Missouri Basin are fed to livestock. The crops produced in 1944 were valued at 2.1 billion dollars compared with 14.4 billion for the United States. The major crops in dollars were: Corn, 813 million; wheat, 495 million; oats, 169 million; alfalfa, 110 million; and barley, 104 million. An important part of the rye, flax, and sugar beets grown in the United States is produced in the Basin (table 3).

The larger part of the farm livestock investment is in cattle. The value of all cattle on farms at the beginning of 1945 was 1.7 billion dollars, compared with 245 million in hogs and 102 million in sheep. (table 4).

Table 3.—Value of Crops Produced, 1944, Missouri River Basin

Crop	United States	Missouri Basin	Percent of U.S. Total
	Mil. Dollars	Mil. Dollars	Percent
Value of specified crops <sup>1/</sup>	14,440	2,090	14
All wheat	1,459	495	34
All corn	3,291	813	25
Oats threshed	721	169	23
Barley threshed	262	104	40
Rye threshed	23	9	39
Flax threshed	60	28	47
Sorghum	307	46	15
Alfalfa cut for hay	606	110	18
Sugar beets	73	26	36
Irish potatoes	520	35	7

<sup>1/</sup>Includes some crops not listed in this table but does not include all minor crops.

Source: 1945 Census of Agriculture

Table 4.--Value of Specified Livestock on Farms, January 1, 1945,  
Missouri River Basin

Type	United States	Missouri Basin	Percent of U.S. Total
	<u>Mil. Dollars</u>	<u>Mil. Dollars</u>	<u>Percent</u>
Horses and mules	974	99	10
Cattle	5,603	1,145	20
Sheep	359	102	28
Hogs	988	245	25

Source: 1945 Census of Agriculture

#### RELATION OF PHYSICAL FEATURES TO ECONOMIC DEVELOPMENT

Certain broad relations of climate and land resources have influenced the development of land and water utilization and policy.

In the humid parts of the country where precipitation exceeds the needs of agricultural production, control and removal of excess water has always been a problem. In such areas federal and State programs have emphasized navigation, flood control, drainage, and control of erosion. Water rights have developed under the riparian doctrine which bases the right to water use on the ownership of land contiguous to a stream.

In the more arid West, precipitation is insufficient for crop production. The mountains yield excess water but supplies from mountain streams are inadequate for all lands that might be irrigated. Special federal and State programs have been developed to stimulate the productive use of water for irrigation in the West. Water rights developed under the doctrine of prior appropriation. This doctrine emphasizes beneficial use and affords protection to enterprises for diverting waters and applying them to lands regardless of whether they are contiguous to water courses.

The transition between these two major climatic zones with their varying history in water and land use policy takes place in the Great Plains part of the Missouri Basin in an area of highly variable climate and an unstable agriculture. In the development of the Basin, the divergent humid and arid water policies have created acute problems. In compromising these conflicts new policies must be developed that recognize this transition zone.

To facilitate description of the Missouri River Basin and its problems, the Basin has been divided into four areas which comprise a very broad grouping of physical land resources (fig. 11).



Upper Watershed.-- This area in the upper reaches of the Basin has a high elevation, mostly above 5,000 feet. It is composed of mountains, mountain valleys, inter-mountain basins, and high plateaus. It contains the largest area of forest land in the Basin and is the source of most of the water for irrigation. Except for irrigated areas, the land is suitable only for limited cultivation. However, its use for grazing, timber, recreation, mining, and water yield makes this an area of great importance.

Western Plains.-- This area contains the great expanse of the semiarid plains broken by the Black Hills where conditions are similar to those found in the Rocky Mountains. The area contains about half of the existing irrigation of the Basin. In favored locations dryland wheat farming has been successful, but rainfall is low and uncertain and production risk is high on most of the non-irrigated cropland. Wind erosion is a serious problem.

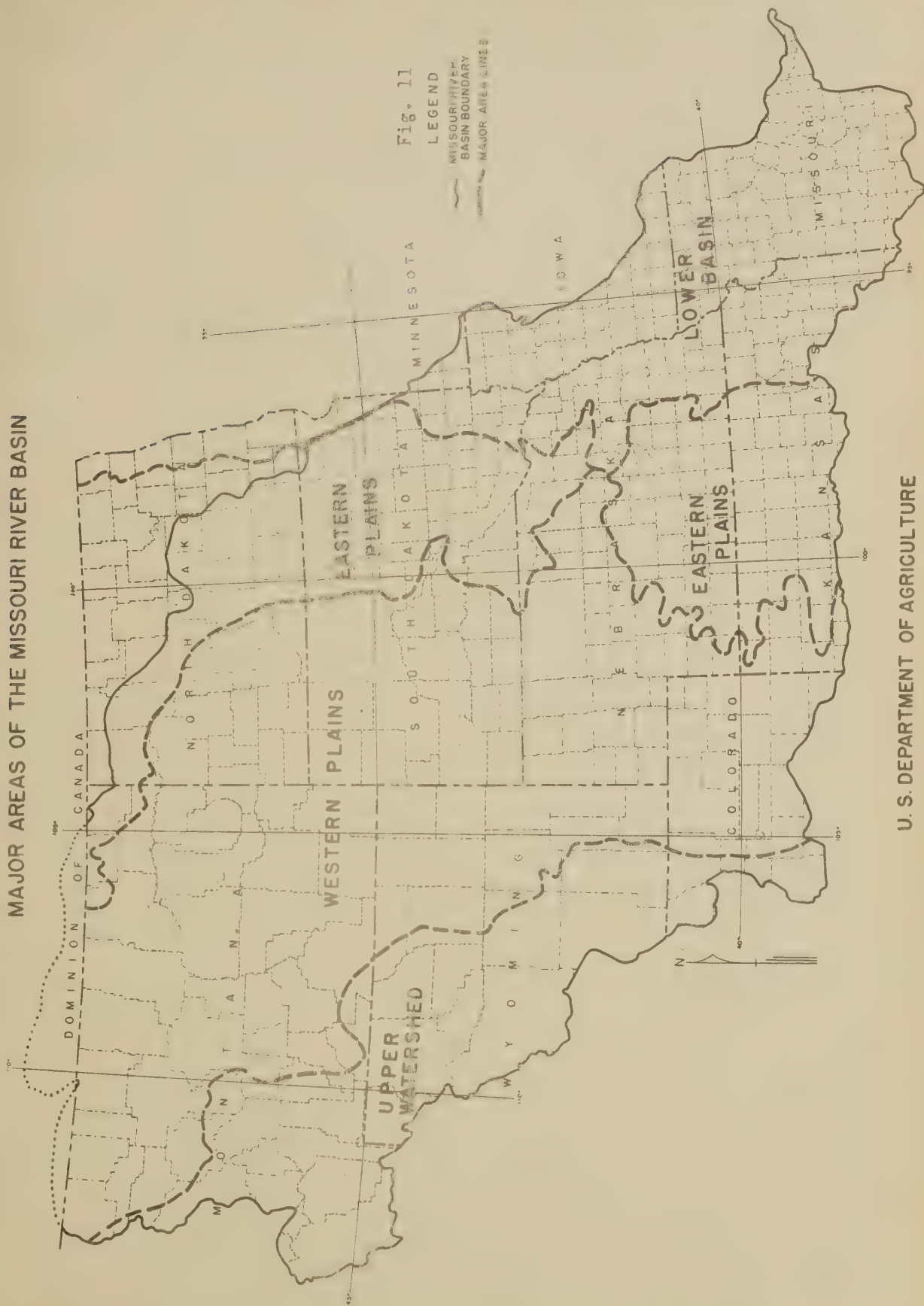
Eastern Plains.-- In this subhumid area, conditions are more favorable to crop production than in the Upper Watershed or the Western Plains. Although rainfall is ample for bumper crops in some years, in other years crops fail for lack of water. The result is a highly variable production. While irrigation has not been practiced extensively in the past, this area contains most of the large projects proposed in the Pick-Sloan Plan.

Lower Basin.-- This southeastern part of the Basin contains parts of two physiographic provinces -- the Central Prairies and Ozark Highlands. The climate is humid and where soils are fertile production is high. Except for the Rocky Mountain areas, water runoff in this area exceeds any other part of the Basin, and soil erosion is seriously damaging the most productive land. Forests now occupy 40 percent of the land area in the Ozark Highlands although 75 percent was originally in forest cover. Overcutting, repeated burning, overgrazing, and attempts at land clearing have reduced the original forests to a mere shadow in both volume and quality. These wooded lands no longer have much commercial value, but they can be improved to provide a greater contribution to the local economy.

## POPULATION

In 1940 the population of the Missouri Basin area was about 6,986,000 of which about 55 percent was in the Lower Basin. The Upper Watershed had only 4 percent of the Basin's population. In the early days of settlement most of the people in the Basin lived on farms or in small towns. In 1920 about 45 percent lived on farms, compared with

# MAJOR AREAS OF THE MISSOURI RIVER BASIN







37 percent in 1940 and about 34 percent at the present time. The proportion of the population living on farms is smallest in the Upper Watershed and highest in the Eastern Plains (table 5).

Table 5.—Total Population, Farm Population and Proportion of Total Population on Farms, 1940, Missouri River Basin <sup>1/</sup>

Area	Total Population	Farm Population	Proportion of Total Population on Farms
Upper Watershed	301,627	82,205	27.3
Western Plains	1,372,321	453,369	33.0
Eastern Plains	1,479,932	760,436	51.4
Lower Basin	<u>3,831,818</u>	<u>1,295,542</u>	<u>33.8</u>
Total	6,985,698	2,591,552	37.1

Source: 1940 United States Census

<sup>1/</sup> These estimates have been computed by including those counties along the border with more than half of their area within the Basin.

### Loss of Population

A major concern of the people of the Missouri Basin is the failure of its population to keep pace with the population growth of the Nation as a whole. Although the national population has increased more than 30 percent since 1920, the population of the Basin has increased very little. The farm population of the Basin reached its peak about 1920, but an ensuing small decline was recovered by 1933. From that time farm population showed a steady decline until 1945. From 1933 to 1945 the loss was about 750,000 farm people or 25 percent. The loss has been relatively greater than in the rest of the United States. After World War II there was some return to the farm in parts of the Basin, but there is evidence that the farm population is again declining. The non-farm population of the Basin has shown an increase of 26 percent since 1920, but it too falls behind the 55 percent increase in the non-farm population of other parts of the Nation and does not make up for the loss in farm population (fig. 12).

These trends have occurred in spite of the large natural increase in the area. Migration to other areas has about equalled the natural increase in the Basin's population. For example, Nebraska had a net emigration of 21,000 annually from 1935 to 1940; 30,000 annually from April 1, 1940 to June 30, 1941; 14,000 annually from July 1, 1941 to June 30, 1945; and 11,000 annually from July 1, 1945 to June 30, 1947. The total loss of population by emigration in this period of 12 years was 228,000, or 18 percent of the 1947 population of the State. Comparable emigration has occurred in other parts of the Missouri Basin. Much of the loss has been from the farm population. This loss in population

has contributed to the lack of, or high per capita cost of, such public services as health facilities, schools and electric power in the more sparsely populated areas.

To the extent that these migrants find better opportunities elsewhere, these adjustments have been desirable from a national viewpoint. The increase in size of farms resulting from the decrease in number of farms has meant, in most cases, better farm organization and higher farm income. But the people in the Basin are asking: Why not create opportunities for these people in the Missouri Basin? Local people want their communities to grow as fast as the rest of the country. They are requesting and are ready to support and participate in sound development programs that promise a sustained production in agriculture, and a steady growth in industries, services, and trade. Such developments would provide a sound base for a stable and growing population.

### Density of Farm Population

The population pattern of the Missouri Basin reveals that the high density of farm population is in the Southeast. This density diminishes in the western and northwestern sections. The greatest density is to be found in western Iowa, Missouri, northeastern Kansas, eastern Nebraska, and the southeastern corner of South Dakota. The wheat-growing area of the Dakotas, Nebraska, and Kansas is next in population density. The range and mountain areas have the lowest density. Scattered through the western area are more densely settled irrigated valleys. These are not shown by Figure 13 which is based on county averages. But the high density in Scotts Bluff County in western Nebraska, where irrigation agriculture is practiced to a large extent, is discernible.

### NUMBER OF FARMS

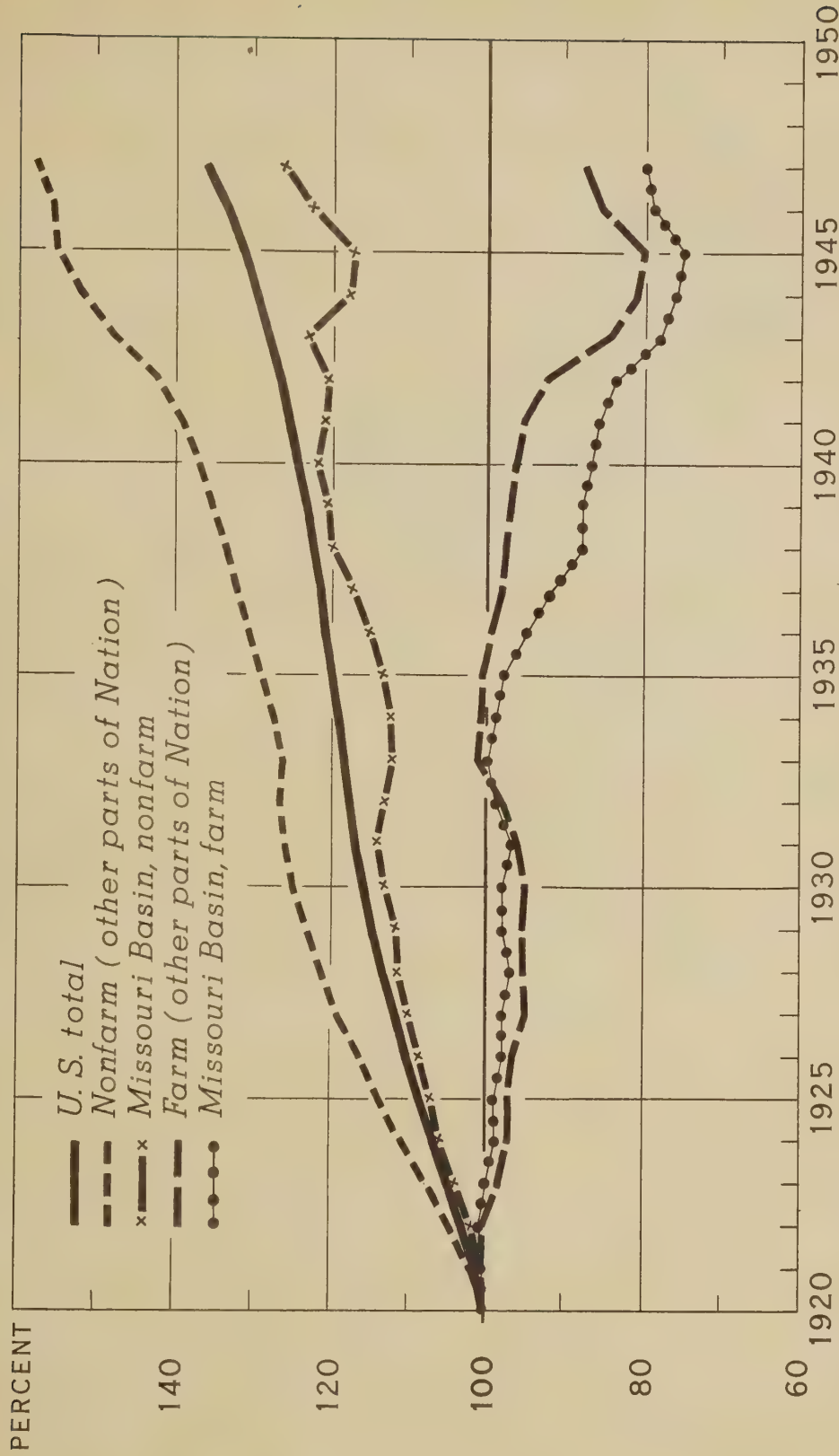
In 1945 there were about 582,000 farms and about 282 million acres in farms in the Missouri Basin. The average size of farms was 485 acres. More than half of the farms (302,000) were in the Lower Basin. This area also had the smallest farms, averaging 173 acres. In contrast, the Upper Watershed had only 16,000 farms, less than 3 percent, with an average size of more than 1,500 acres (table 6).

Table 6.—Number and Average Size of Farms by Areas, Missouri River Basin

Area	Number of Farms	Land in Farms	Average Size
	Number	Acres	Acres
Upper Watershed	15,738	24,310,529	1,545
Western Plains	91,835	128,723,779	1,402
Eastern Plains	173,245	76,985,113	444
Lower Basin	301,172	52,033,596	173
Total	581,990	282,053,017	485

Source: 1945 Census of Agriculture.

# TRENDS IN POPULATION OF THE UNITED STATES AND THE MISSOURI BASIN INDEX NUMBERS (1920=100)



SOURCE: BUREAU OF CENSUS AND BUREAU OF AGRICULTURAL ECONOMICS.  
INDEXES FOR MISSOURI BASIN COMPUTED BY GIVING EACH STATE A WEIGHT  
BASED ON ITS PORTION OF MISSOURI BASIN POPULATION IN 1945

U.S. DEPARTMENT OF AGRICULTURE

NEG. 47186 BUREAU OF AGRICULTURAL ECONOMICS

Figure 12.- Population growth in the Missouri Basin has not kept pace with the rest of the nation.





# DENSITY OF FARM POPULATION, MISSOURI BASIN, 1945.

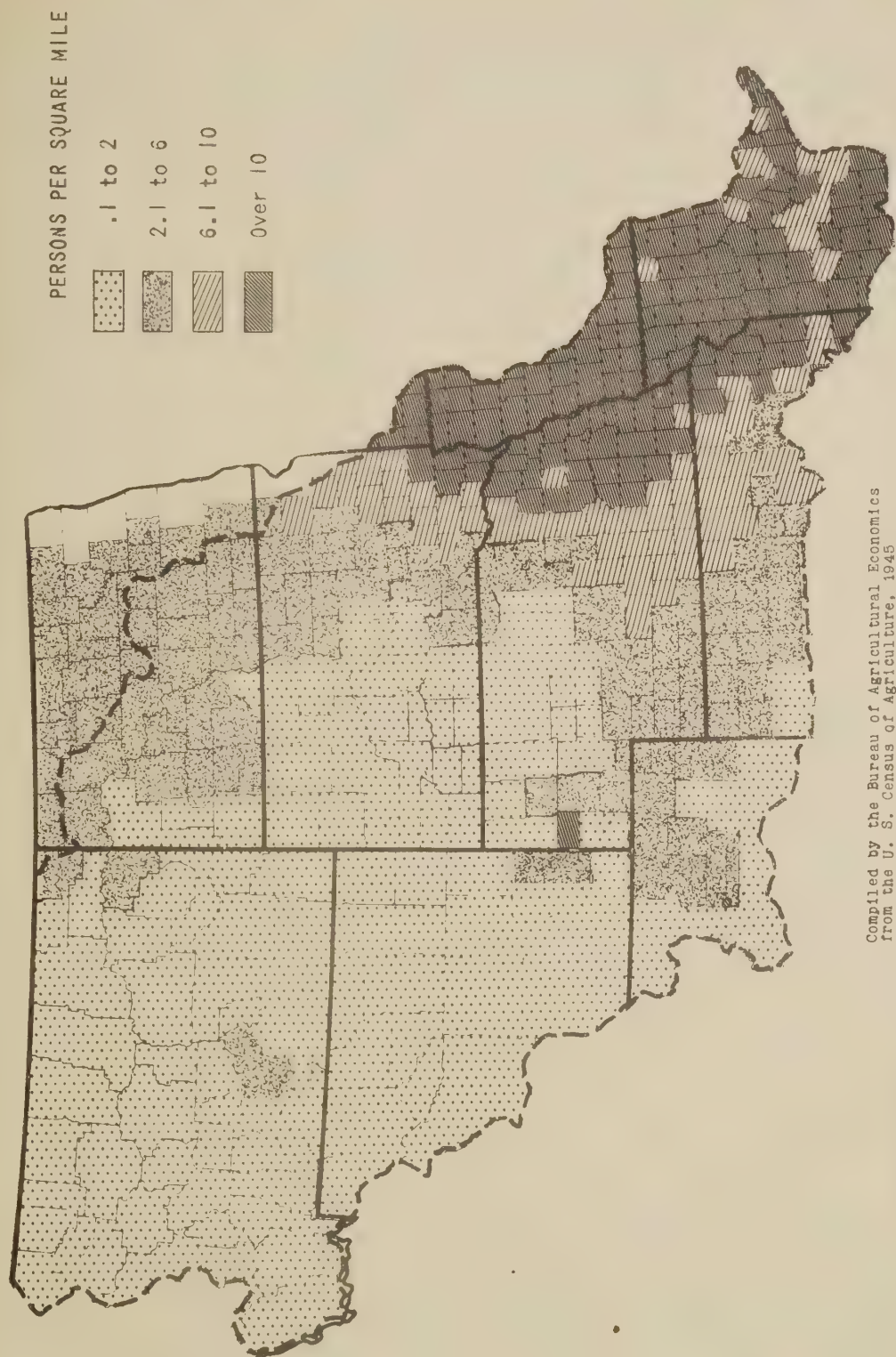


Figure 13.- Farm population density decreases from the southeastern part of the Basin to the west.





From 1935 to 1945 the number of farms in the Basin declined 116,000 or 16.7 percent (table 7). The maximum number of farms was probably reached in 1935. The decrease during the period 1935 to 1945 due to drought, depression, and the war period was so severe that the Basin probably has fewer farms now than in 1910. In Nebraska and Kansas there were less farms in 1945 than in 1890, in Iowa and Missouri less than in 1900, in North and South Dakota less than 1910, and in Montana, Wyoming and Colorado less than in 1920.

Much of the land was homesteaded in 160-acre units. The subsequent consolidation has been mainly the result of the mechanization of farming, drought and depression, which forced many farmers from the land, and the opportunities for wartime industrial employment, which attracted many others.

Production has not declined as a result of reduction in the number of farms. The land has been absorbed into adjoining farms for mechanization enables one man to handle more land.

Table 7.—Trend in the Number of Farms by Areas, Missouri River Basin, 1930-1945.

Area	1930	1935	1940	1945	Decrease in Number of Farms 1935 to 1945	
	No.	No.	No.	No.	No.	Pct.
Upper Watershed	16,917	18,755	16,635	15,738	3,017	16.1
Western Plains	121,054	125,868	102,185	91,835	34,033	27.0
Eastern Plains	206,121	213,265	188,507	173,245	40,020	18.8
Lower Basin	323,083	340,381	315,289	301,172	39,209	11.5
Total	667,175	698,269	622,616	581,990	116,279	16.7

Source: 1945 Census of Agriculture, 1940 United States Census.

## LAND USE

The Missouri Basin's land area is largely utilized in agriculture with 83 percent of the land in farms in 1945. In the Lower Basin 92 percent was in farms, in the Eastern Plains 94 percent, in the Western Plains 84 percent, and in the mountainous Upper Watershed only 50 percent. Much of the Upper Watershed is in public ownership. Although it is not included in farms and ranches, most of it is used for grazing.

With the exception of parts of Missouri, the eastern portion of the Basin has the highest intensity of cultivation (Figure 14). In general, the proportion of cropland declines from east to west in the Basin, except where conditions are favorable for wheat production or where irrigation agriculture is important. The principal exception is found in the Ozark highlands where the proportion of cropland is relatively small.

Table 8.—Land Use in the Missouri Basin

Type of Use	:	Area
	:	<u>Million Acres</u>
Cropland	:	113
Grassland	:	175
Forest and woodland	:	45
Other uses	:	7
Total	:	340

Cropland in the Basin is estimated at 113 million acres, including rotation hay and pasture, at the present time. There are 175 million acres of open grassland. Forest and woodland are estimated at 45 million acres, some of which are used for grazing. Other uses, such as roads, towns and parks, account for 7 million acres.

In the Lower Basin and the Eastern Plains, more than half of the land is used for crops compared with 18 percent in the Western Plains and only 5 percent in the Upper Watershed. Seventy percent of the cropland in the Basin is located in the Eastern Plains and the Lower Basin.

Grassland is of major importance in all parts of the Basin. The highest proportion of grassland occurs in the Western Plains with 63 percent, and the Upper Watershed with 59 percent. In the Eastern Plains 39 percent of the land is in grass and in the Lower Basin 28 percent.

Forest and woodlands are important as a land use in the Upper Watershed, the Western Plains, and the Lower Basin but occupy a small portion of the lands in the Eastern Plains. A large part of the forest and woodland in the two western areas is in national forests and on other public land, but in the Lower Basin it is on private land, much of which is in farm units.

According to the Census of Agriculture, irrigated land in the Missouri Basin increased by more than 1 million acres from 1934 to 1944, and the farms reporting irrigation increased by 3,600 (table 9). The increase in farms was entirely in the Plains areas. In the Upper Watershed and the Lower Basin, there was a decrease in the number of irrigated farms.

Table 9.—Irrigated Land in Farms 1934, 1939, and 1944, Missouri River Basin <sup>1/</sup>

Year	:	Farms Reporting	:	Area Irrigated
	:	<u>Number</u>	:	<u>Acres</u>
1934	:	34,300	:	2,853,000
1939	:	36,700	:	3,650,000
1944	:	37,900	:	3,903,000

<sup>1/</sup>The Census of Agriculture reports land irrigated as reported by individual farmers. The figure is generally somewhat smaller than that obtained through the Census of Irrigation which is taken from managers of irrigation enterprises. For example, the Census of Agriculture reported 3,650,000 acres irrigated in the Missouri Basin in 1939, and the Census of Irrigation reported 4,400,000.



PROPORTION OF LAND AREA USED FOR CULTIVATED AND HAY CROPS, MISSOURI BASIN, 1944.

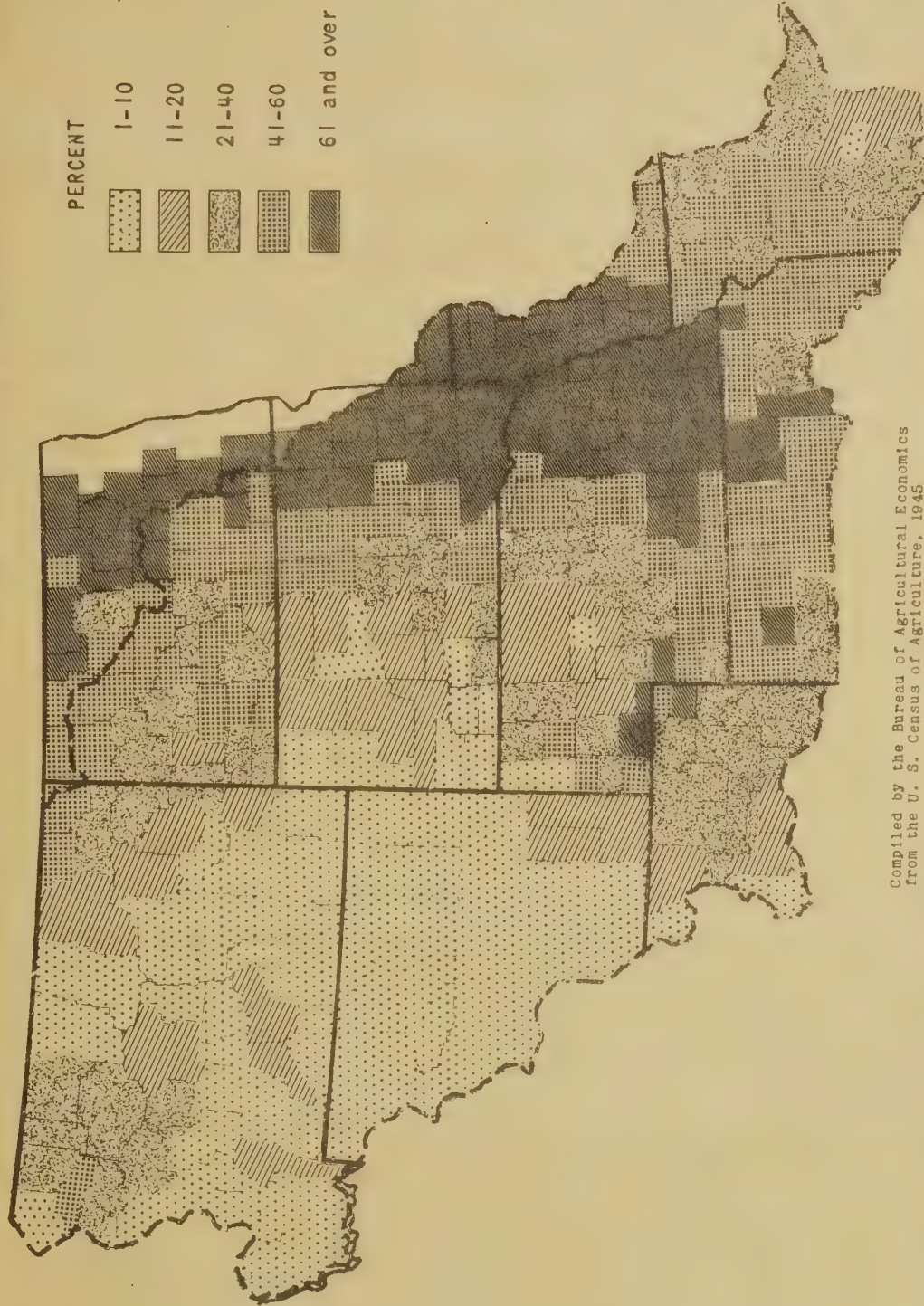


Figure 14.- The proportion of cropland is highest in the eastern part of the Basin.





About 70 percent of the farms in the Upper Watershed reported irrigation. Irrigation is also important in the Western Plains although only 25 percent of the farms there reported water used for that purpose. Irrigation was practiced on a very small proportion of the farms in the Eastern Plains and the Lower Basin. In the Missouri Basin as a whole only 6.5 percent of the farms reported some land irrigated in 1944. (Table 10).

Table 10.—Proportion of Farms Reporting Irrigation in 1944, by Areas.  
Missouri River Basin

Area	All Farms	Farms Reporting Irrigation	
		Number	Percent
Upper Watershed	15,738	11,107	70.6
Western Plains	91,835	22,862	24.9
Eastern Plains	173,245	3,813	2.2
Lower Basin	301,172	134	—
Total	581,990	37,916	6.5

Source: 1945 Census of Agriculture

#### FARM INCOME

The Missouri Basin has experienced wide extremes in total farm income. Drought and low prices combined to produce very low farm income during the 1930's in contrast with the favorable weather and high prices which combined to produce high farm income during the 1940's.

Income from the sale of crops has been especially erratic. The year-to-year variation, compared to the average of the 24-year period 1924 to 1947, is given in Figure 15. The period from 1924 to 1929 was relatively stable at about the 24-year average. In the drought period 1931 to 1940 income from the sale of crops was very low. The low point of the period occurred in 1934. Wartime demand and prices and almost ideal weather produced the record-breaking income of the period 1942 to 1947. In 1947, income from crops reached a high of over 3 times the average of the 24-year period. But during periods of high prices, farm costs increase so much that a decline in income through either drought or price decline results in farm distress.

About 45 percent of the farm income was produced in the Lower Basin, where livestock and livestock product sales exceeded crop sales four to one. The Eastern Plains produced about 30 percent of the total income. In this area sale of crops was more important as a source of income than livestock and livestock products. Although the Upper Watershed and the Western Plains combined has about 60 percent of the land area, they produced only 25 percent of the total income (table 11).

Table 11.—Value of Farm Products Sold or Used by Farm Households by Areas, Missouri River Basin, 1944

Area	Total	Crop	Livestock & Livestock Products	Forest <sup>1/</sup> Products	Used by Farm Households
	Thousand Dollars	Thousand Dollars	Thousand Dollars	Thousand Dollars	Thousand Dollars
Upper Watershed	103,361	26,331	72,078	66	4,886
Western Plains	559,640	242,584	287,997	155	28,904
Eastern Plains	833,337	400,636	373,011	121	59,569
Lower Basin	1,209,550	233,504	868,857	923	106,266
Total	2,705,888	903,055	1,601,973	1,265	199,625

<sup>1/</sup> Does not include timber cut from national forests and other land not considered in farms.

Source: 1945 Census of Agriculture

Income per acre is highest in the Corn Belt areas of Iowa and Nebraska (Figure 16). The wheat and general farming areas are next as income producers. The grassland areas generally are lowest in income per acre, except for those counties that have considerable irrigated land.

#### Low-Income Farms

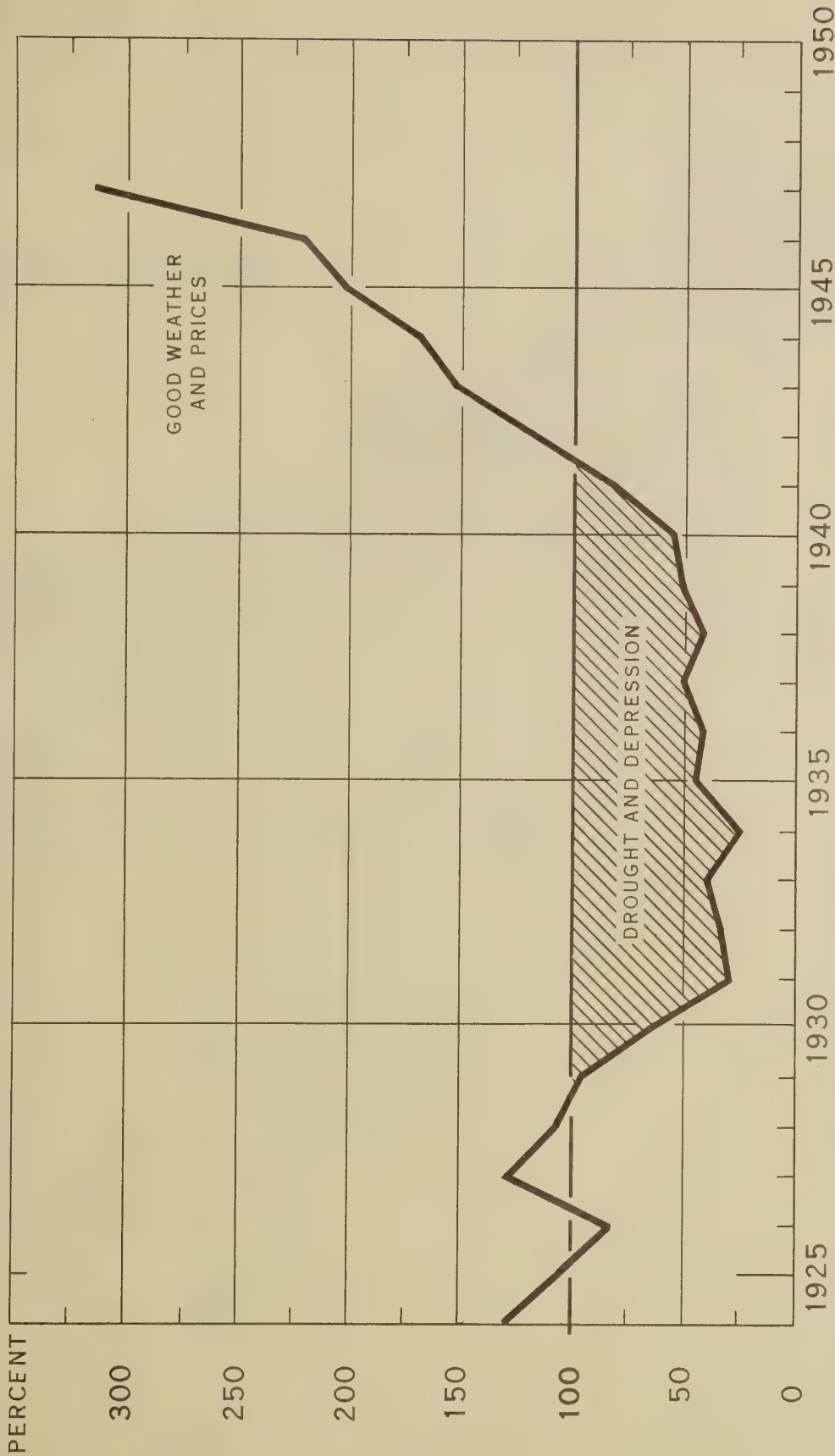
Widely fluctuating farm income is a major problem in the Missouri Basin. However, there is also a problem of chronic low-income farms. In 1944, 149,000 farms, or 26 percent of all farms, had gross incomes of less than \$1,500, representing only 4 percent of the total farm income in the Missouri Basin. The distribution of these farms by counties is shown in Figure 17.

In the group of 149,000 farms with incomes of less than \$1,500 are many part-time units or rural residences. The operators of these units are only partially dependent on the farm for their livelihood. The problem farms are those small income units with no other source of income. Although exact information on this type of unit is not available for the Missouri Basin, small scale farms in the area are estimated at about 50,000 in number.<sup>1/</sup> These units are characterized by a small investment in land, small acreage of cropland, small investment in livestock, and inadequate machinery and equipment. Few of them have running water, electricity, telephones, and other modern facilities.

<sup>1/</sup> Estimate based on comparison of the 1945 Sample Census for the Missouri Basin States with the farm income distributions in the Missouri Basin.



# FARM INCOME FROM SALE OF CROPS, MISSOURI RIVER BASIN INDEX NUMBERS (1924-47 = 100)



SOURCE: INDEX FOR MISSOURI BASIN COMPUTED BY USING BUREAU OF AGRICULTURAL ECONOMICS CROP INCOME ESTIMATES BY STATES. EACH STATE GIVEN A WEIGHT EQUAL TO ITS CONTRIBUTION TO BASIN CROP INCOME IN 1944

Figure 15.- Extreme variation in income from the sale of crops characterize the Basin.



VALUE OF FARM PRODUCTS PER ACRE, MISSOURI BASIN, 1944.

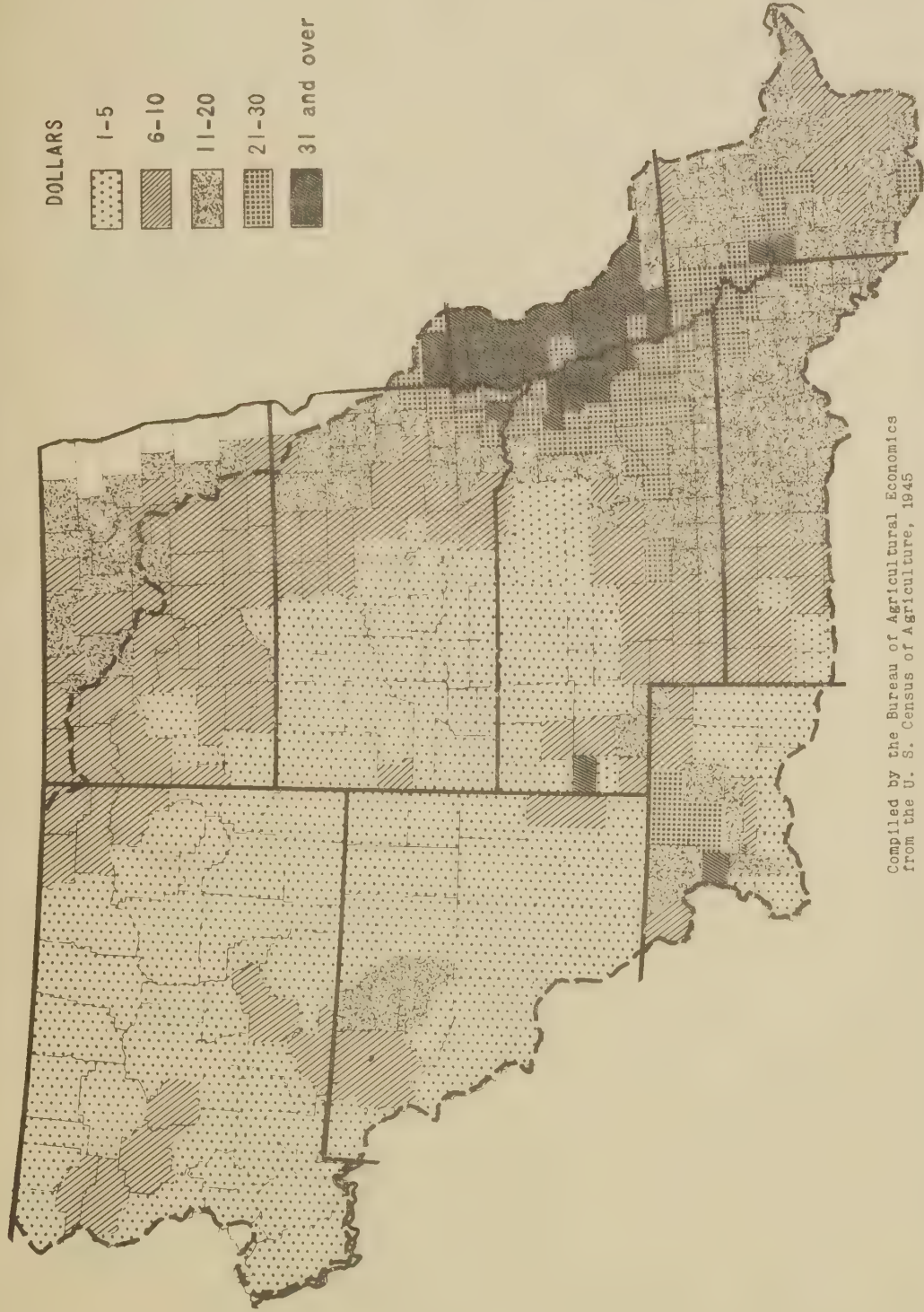


Figure 16.- The Corn Belt area of western Iowa and eastern Nebraska is the highest producer of farm products.





PROPORTION OF FARMS WITH INCOME UNDER \$1500, MISSOURI BASIN, 1944.

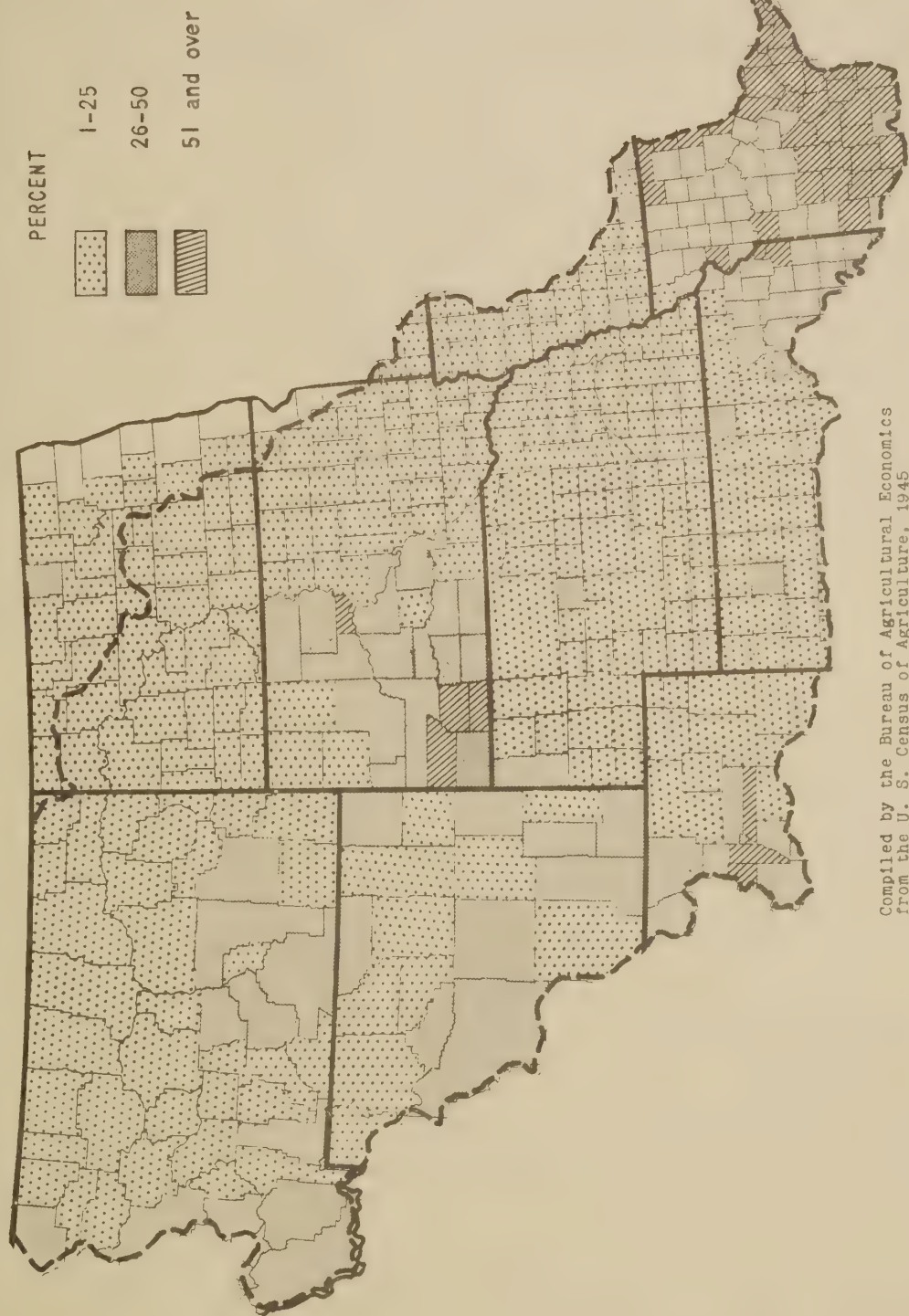


Figure 17.- One-third of the farms reporting incomes under \$1500 are small-scale farms with little non-farm income.





In many cases these small-scale farms are on land that presents a serious problem of erosion control. The farmers are often financially unable to participate in conservation programs. Public programs of education and assistance in land conservation are confronted with special problems of reaching this group of farmers. As this important group often has numerous representatives in critical areas, special provisions are needed to meet this situation.

### FARM VALUATION

The total farm valuation in the Missouri Basin in 1945 was 9.1 billion dollars with about half of the total value in the Lower Basin. The largest investment, 6.6 billion dollars, was in land and buildings. The value of livestock was 1.7 billion, and farm implements were valued at .8 billion.

The highest values center around the Corn Belt area of western Iowa and eastern Nebraska (Figure 18).

### LAND OWNERSHIP AND TENURE

#### Land Ownership

About 72 million acres of the 340 million in the Missouri Basin are in public ownership. Farm operators own about 147 million acres and the rest is owned by non-farm individuals or private institutions. Public ownership is concentrated in the western part of the Basin. More than one-half of the land in the Upper Watershed is publicly owned and one-fourth of the land in the Western Plains is so owned. In contrast, only 5 percent of the land in the Eastern Plains is in public ownership, and in the Lower Basin less than one-half million acres (Figure 19).

Farm operators own 48 percent of the land in the Lower Basin. The Western Plains and the Eastern Plains are nearly as high with 46 and 43 percent. In the Upper Watershed farm operators own 30 percent of the land. Non-farm individuals and private institutions form the largest ownership group in the Eastern Plains and the Lower Basin with more than half of the land. In the Western Plains, this group owns 29 percent, and in the Upper Watershed 10 percent.

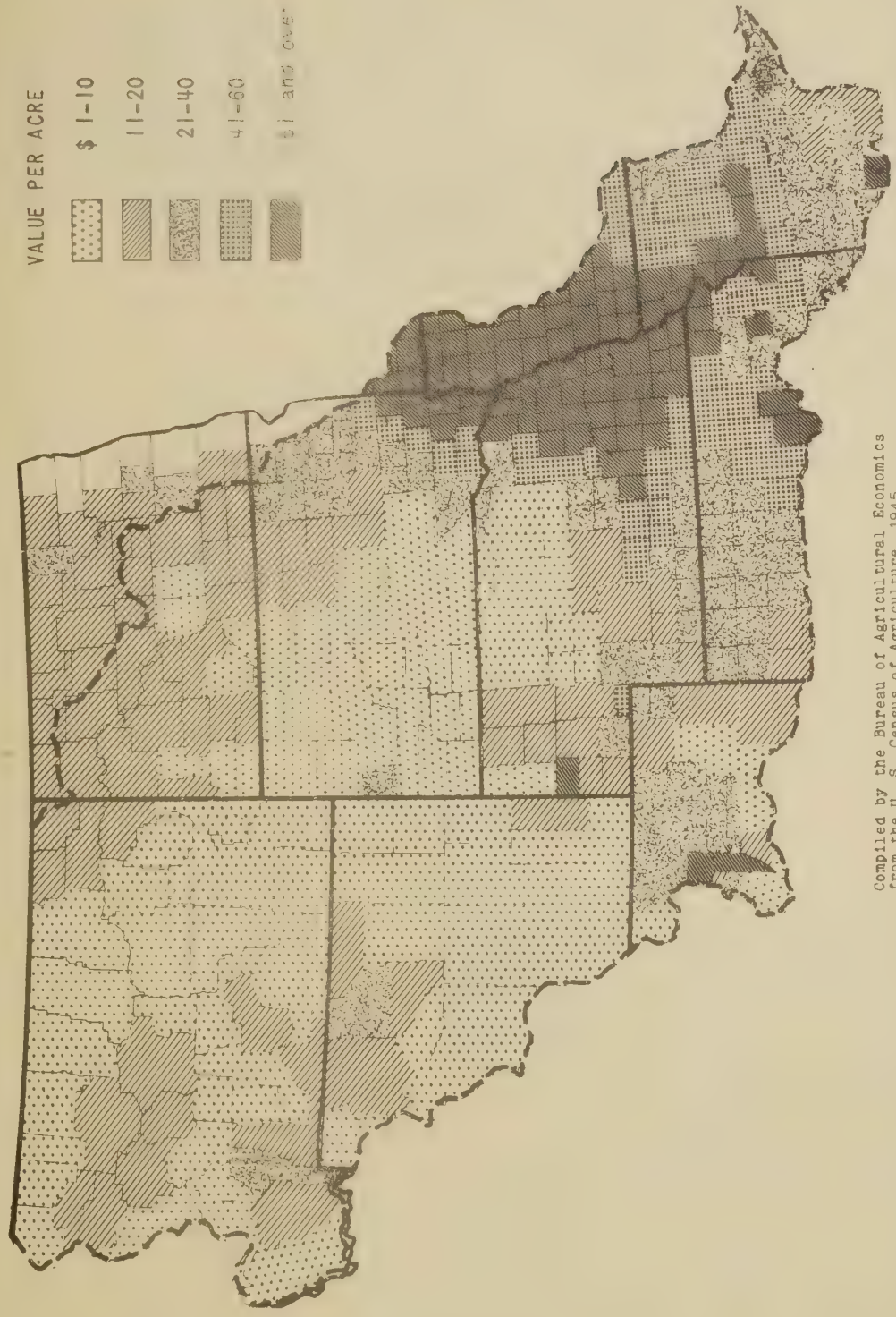
Both federal and State ownership are concentrated in the Upper Watershed and the Western Plains (table 12). The major agencies that administer land in federal ownership are the Bureau of Land Management, the Forest Service, and the Office of Indian Affairs. School endowment lands represent the major type of State ownership.

Table 12. -- Federal and State Owned Lands, by Areas, Missouri River Basin

Type of Ownership	: Upper Watershed : Western Plains		: Eastern Plains : Lower Basin		Total
	Thou. Acres	Thou. Acres	Thou. Acres	Thou. Acres	Thou. Acres
<b>Federal</b>					
Bureau of Land Management	9,877	7,161	61	1	17,100
Forest Service.	12,439	4,204	1	145	16,789
Soil Conservation Service	-	4,582	58	14	4,654
National Defense	96	1,081	133	112	1,422
Parks and Wildlife	1,626	736	202	37	2,651
Indian Lands	2,013	10,478	1,662	104	14,257
Other	13	170	25	4	217
Total Federal	26,069	28,462	2,142	417	57,090
<b>State</b>					
Forest	112	99	-	-	211
Parks	2	6	8	2	18
Credit Agencies	-	14	19	-	33
School Lands	3,073	9,246	2,652	17	14,993
Total State	3,192	9,365	2,679	19	15,255
<b>TOTAL FEDERAL AND STATE</b>	29,261	37,827	4,821	436	72,345

Source: Compiled by BAE in cooperation with SCS from various sources. Data are from different years but mostly since 1945.

VALUE OF FARM LAND AND BUILDINGS PER ACRE, MISSOURI BASIN, 1945.



Compiled by the Bureau of Agricultural Economics  
from the U. S. Census of Agriculture, 1945

Figure 18.- Farm land values are generally higher in the Corn Belt area than in other parts of the Basin.





# LAND OWNERSHIP BY MAJOR AREAS OF THE MISSOURI RIVER BASIN

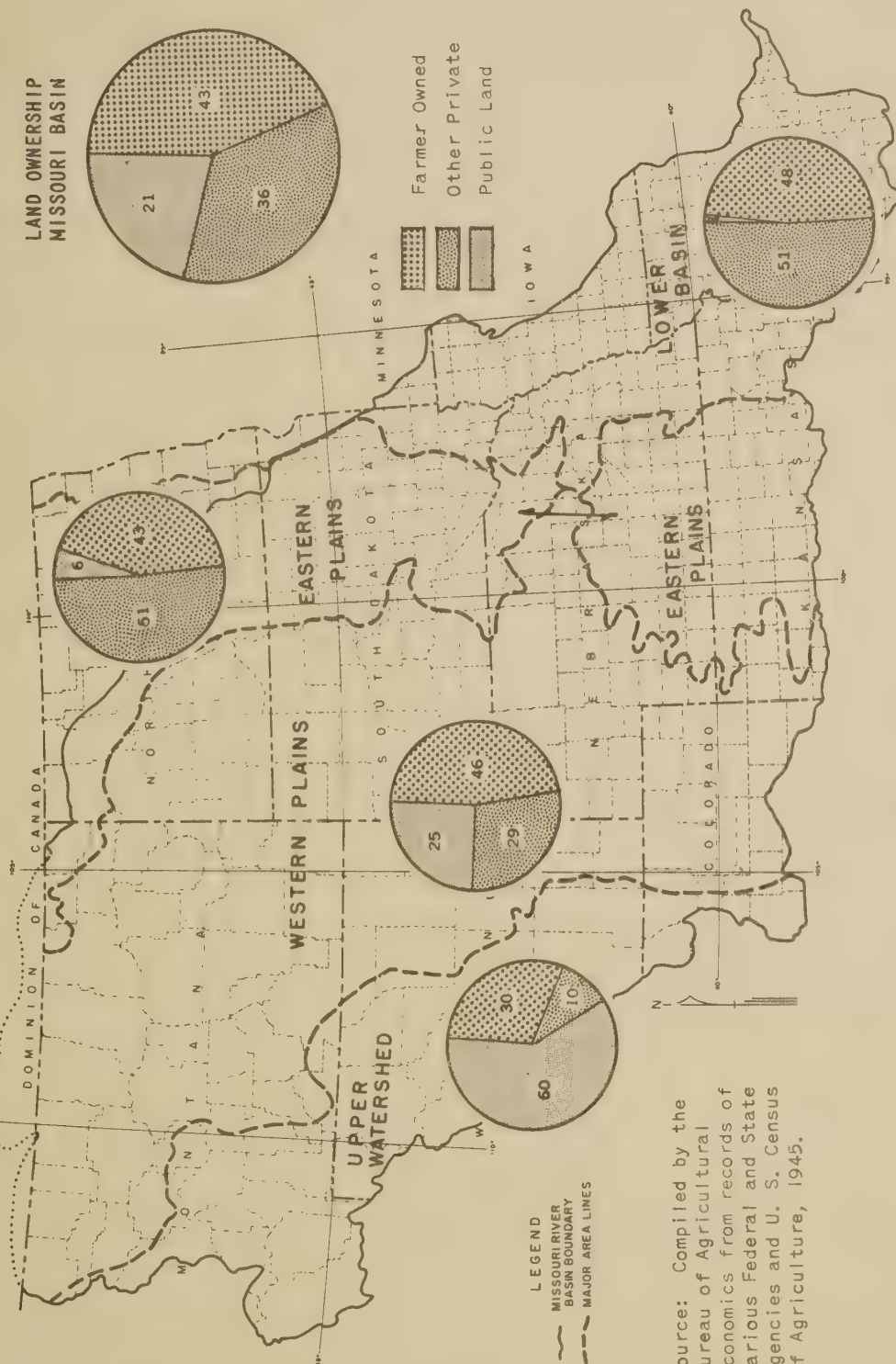


Figure 19.- Public ownership occurs mostly in the western Plains and upper watershed areas.





### Tenure of Farm Operators

In 1945, 234,000, or 40 percent, of the farm operators in the Missouri Basin owned all the land they operated; 143,000 farm operators, or 24 percent, owned part of their farms and rented part. Thus 64 percent of the farm operators owned some land. There were 202,000 tenant operators that did not own any of the land in their farms. This group made up 35 percent of the farm operators. Only 1 percent of the farms were operated by hired managers. The proportion of full owners was highest in the Upper Watershed and Lower Basin, and lowest in the Eastern Plains. The proportion of part owners was highest in the Western Plains and lowest in the Lower Basin. There was not so much variation in the proportion of full tenants. The Eastern Plains was highest with 38 percent, and the Upper Watershed lowest with 23 percent (table 13).

Share leasing is the predominant type of lease in all areas. Combination share-cash leases account for about a third of the leases in the Eastern Plains and the Lower Basin, but are less important in the Upper Watershed and the Western Plains. About a third of the leases in the Upper Watershed were cash leases, compared with a fourth in the Western Plains and the Lower Basin. Only 6 percent of the leases in the Eastern Plains were for cash.

### Relation of Farm Ownership and Tenure to Land Management and Conservation

Effective conservation programs depend on the full cooperation of both owners and operators of land. This is the case whether improved techniques of management, practices to protect land, or structures for retarding waterflow are involved.

Many kinds of land improvements are costly, but most will pay for themselves in time. Once owner-operators understand the benefits to be derived, most of them will feel like going ahead with their share of the necessary improvements. But owner-operators are not always able to finance the improvements.

When ownership and operatorship are separated, as is the case with more than half the land in the Basin, the problems are more complicated. There is the question of equitable distribution of costs and returns between landlord and tenant for improvements. New practices often require new standards. Existing legislation and custom are often inadequate as guides for landlords and tenants when new measures or new methods are involved.

Tenants may lack incentives because returns on investments often are spread over many years, but few tenants have any assurance of a lease beyond the current year. There is little incentive for them to invest or put forth effort if there is no assurance of being able to share in the benefits. Furthermore, when a tenant invests his own funds and effort to improve the land he needs to be assured that the landlord will not increase the rent because of the improvement.

Table 13. - Tenure Status of Farm Operators by Areas, Missouri River Basin.

Area	Total Number		Full Owners		Part Owners		Tenants		Managers	
	Number	Pct.	Number	Pct.	Number	Pct.	Number	Pct.	Number	Pct.
Upper Watershed	15,738	100	8,246	52	3,615	23	3,554	23	323	2
Western Plains	91,835	100	29,976	33	36,502	39	24,666	27	691	1
Eastern Plains	173,245	100	48,450	28	56,333	33	67,943	38	519	1
Lower Basin	301,172	100	147,198	49	46,645	15	106,118	35	1,211	1
Total	581,990	100	233,870	40	143,095	24	202,281	35	2,744	1

Source: 1945 Census of Agriculture

Thus, conservation programs can be accelerated when problems of finance for both owners and tenants, equitable distribution of returns, equitable landlord-tenant relationships, and increased ownership by operators receive adequate consideration.

## FOREST LANDS

The forest lands of the Missouri Basin comprise only 14 percent of the area, but they are of vital importance to the people of the Basin.

The term, "forest land," is used here to include intermingled and adjoining forest range lands, mountain peaks above the timber line, and small wooded areas scattered throughout the farming areas of the Plains States. Lands not supporting trees at present but which are better adapted to forest than any other use likewise are included in the forest lands. The distribution of forest land by ownership is:

National forest.....	16,345,000 acres
Other federal ownership.....	5,089,000 acres
State, county and municipal....	566,000 acres
Private farm (including shelterbelts and wind- breaks).....	14,829,000 acres
Private non-farm.....	8,171,000 acres

The National Forests cover much of the high Rocky Mountain area (Figure 20). A large proportion of the other federal land is located in the high plains bordering the mountains. This is principally under the jurisdiction of the Department of the Interior. In the Ozark highlands of the southeastern part of the Basin is found the greatest concentration of forested land outside of the Rocky Mountain area. Most of this is in private ownership.

### Forests As a Regulator of Water Supply

Forest lands are important sources of water. The Great Plains obtains its irrigation water primarily from the Rocky Mountain headwaters of the South and North Platte, Yellowstone, and Missouri Rivers. Water for industrial and domestic use also flows from these mountain lands which are remote from the areas of greatest water use.

The national forests, which cover much of the high Rocky Mountain area, play the major role in the Basin's western water supply (Fig. 20). At the higher elevations, snow-melting extends into late spring and early summer, making water available when downstream requirements are high. For example, about 40 percent of the runoff from the national forests of Colorado and Wyoming takes place in June and July.



The average annual flow of water from the 16 million acres within the national forests of the western part of the Basin is estimated at approximately 12 million acre feet. This is more than one-third of all the water potentially available for irrigation.

Numerous impoundments have been constructed for irrigation and power within the western forested area, many of which are within the national forests. Much of the water impounded further downstream for irrigation and as an aid to navigation also comes from the forests of the Rocky Mountain area. Some 45 cities, towns, and rural communities with a total population in 1940 of 590,000 people, are dependent upon water that flows from these national forests for their domestic water supply. In addition, an unknown, but sizable, volume reaches underground basins from which it is recovered for irrigation and domestic use.

### Timber Production

Timber contributes only a fraction of what it could to the development and stability of the Basin economy. The values that may be realized would be reflected not only in local use of the timber for lumber and other wood products, but also in the establishment of new industries, more opportunities for employment, new buyers for local products, and many other ways.

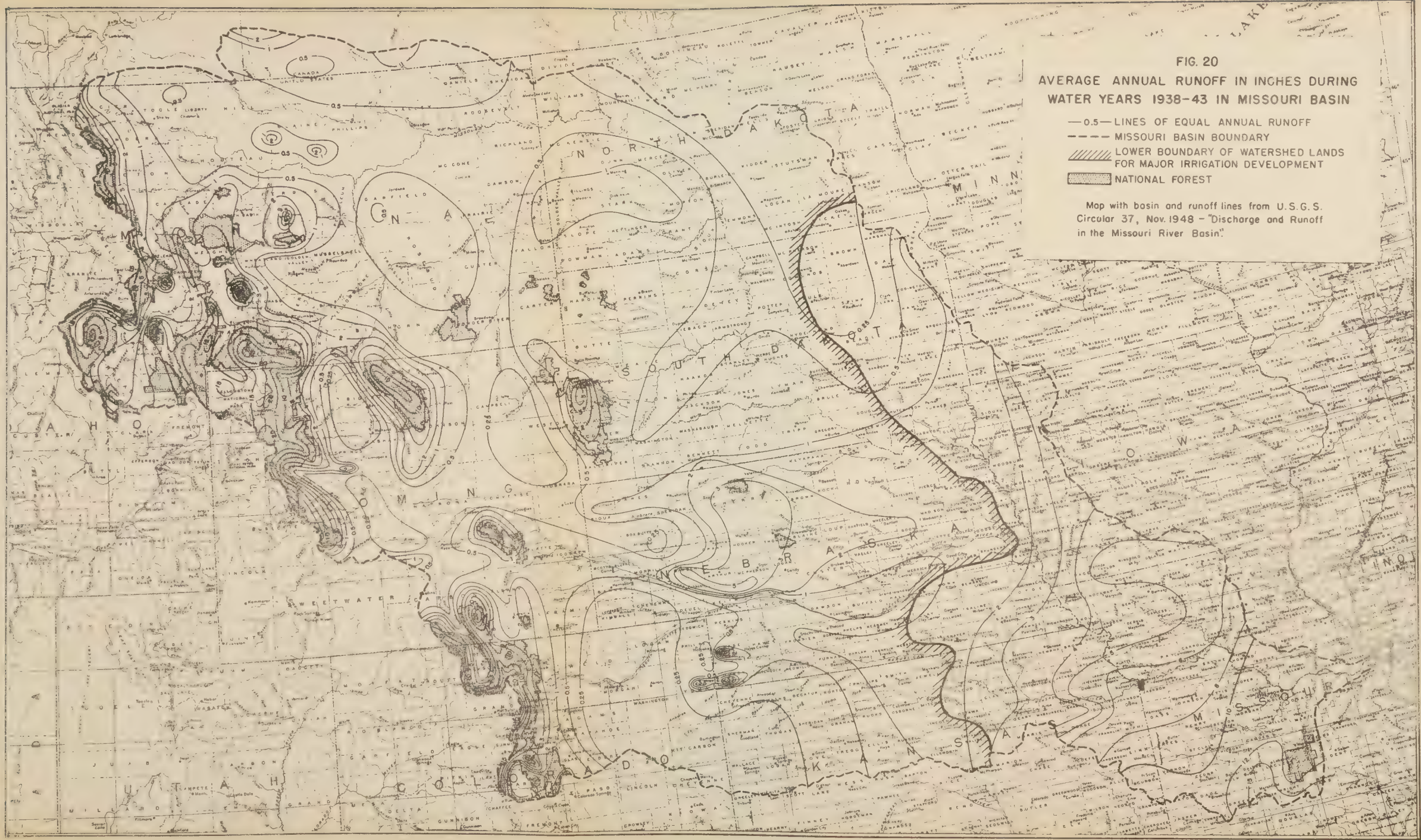
Ownership and growth of the forest land which can produce timber in commercial quantity and quality are shown by table 14.

Table 14.—Ownership and Condition of Commercial Forest Lands in the Missouri River Basin

	: Federal :		State	: Private :		
	: National: Other :		County	: : :		Total
	: Forest :Federal:		Municipal	: Farm :Non-farm:		
	: Thousand :		Thousand	: Thousand :		Thousand
	: Acres :		Acres	: Acres :		Acres
Saw timber	: 3,235	: 364	: 154	: 1,824	: 437	: 6,014
Pole timber	: 3,173	: 331	: 154	: 3,383	: 1,000	: 8,041
Seedlings and saplings	: 1,252	: 183	: 47	: 2,075	: 609	: 4,166
Poorly stocked and denuded	: 238	: 82	: 38	: 2,013	: 387	: 2,758
Total	: 7,898	: 960	: 393	: 9,295	: 2,433	: 20,979

Forty-five percent of the commercial forest land is on farms and 38 percent in the national forests. Four-fifths of the public forests are in either saw-timber or pole-timber stages of growth; but almost half of the private forest lands are in seedlings and saplings, or are









poorly stocked and denuded. This contrast is reflected in estimates of saw-timber volume: 70 percent of the 29.3 billion board feet in the Basin is on the national forests. Ownership of saw-timber on commercial forest lands is as follows:

National forest	20,676,000,000 board feet
Other Federal ownership	2,267,000,000 board feet
State, county and municipal	544,000,000 board feet
Private farm (including shelterbelts and windbreaks)	4,713,000,000 board feet
Private non-farm	<u>1,073,000,000 board feet</u>
Total	29,273,000,000 board feet

The forests of the Basin supply less than 20 percent of the area's present annual consumption of lumber which is estimated at 857 million board feet. A similar situation exists for most timber products, although wood for fuel is a notable exception. High freight charges and limited competition in distribution have added to the cost of lumber and other wood products in the Basin.

The annual cut of timber from the national forests in the Basin, approximately 150 million board feet, is less than half of the volume that might be removed. The present output is being used for lumber, poles, mine timbers, pulpwood (for shipment to the Lake States), fence posts and fuelwood. There are large blocks of mature timber, principally ponderosa pine, lodgepole pine, Douglas fir, and Engelmann spruce, in the Rocky Mountains which still lack roads to make them accessible for cutting.

#### Shelterbelts and Windbreaks

Tree planting on the plains has been undertaken from the days of the early settlers. Early plantings for protection of farmsteads from wind and sun were followed by more extensive efforts to produce timber, to protect fields from wind erosion and to provide more favorable conditions for production of cultivated crops. In the 1930's a vigorous organized cooperative program between farmers, State agencies and the federal government greatly accelerated the rate of shelterbelt planting and extended it into the driest portions of the high plains. This joint undertaking has been terminated but the planting has continued at a reduced rate. Some 96,168 miles of shelterbelts and windbreaks have been established. The values of plantings have been clearly demonstrated in sundry uses such as protecting buildings and roadways, checking wind erosion, conserving moisture, sheltering livestock and encouraging growth of wildlife populations. Interest in windbreak and shelterbelt planting is now widespread throughout the plains area of the Basin.

### Grazing Use

Forest ranges are found principally within or near the national forests in Colorado, Wyoming, Montana and South Dakota, and to some extent in Missouri. They are of primary importance to the economic stability of several thousand livestock operators and the welfare of the communities in which the ranges are located. These areas consist of brush, grass, and weeds intermingled with or near forested lands, stringers of feed along mountain streams, mountain meadows at the higher elevations, and open glades in the eastern part of the Basin.

The need for supplemental feed for livestock from this source is particularly prevalent among the nearby small owners. This is illustrated on the Black Hills and Harney National Forests in South Dakota. The majority of the 600 ranchers who have permits to graze livestock on the national forest lands live on small ranches within the national forests. The grazing of beef and dairy cattle, horses, and sheep is closely integrated with the production of crops and part-time work in other types of employment. Thus the use of the forest range contributes materially toward the support and general welfare of 10,000 to 12,000 people within this area.

A large part of all the national forests in the basin are grazed by livestock. During 1947 these forest ranges were distributed among approximately 3400 livestock operators who grazed about 231,000 head of cattle and 586,000 head of sheep. The use totaled approximately 1,010,600 cow months and 1,270,900 sheep months. In addition, about 100,000 calves and 500,000 lambs under six months of age were also fed.

The forest ranges in the western part of the Basin usually are used for grazing during the four summer months. While the season is short, it is a critical period for the livestock operator. The animals make their greatest gains in weight in this period.

More than 70 percent of the woodlands in the Ozark Highlands is grazed in varying intensity. In many cases the need for shade and shelter to protect livestock from sun and wind and the lack of adequate fencing to control or distribute livestock use have reduced the carrying capacity of the ranges. The clearing of wooded areas for pasture by killing and burning the timber, followed with grazing by goats, often causes heavy top soil losses. With these practices, feed has become scarce and low in nutritional value. Estimates show that 20 to 80 acres are required to furnish enough feed for each head of cattle for an 8-month grazing season. The results of continuous trampling and excessive grazing show up in reduced feed, in compacted soil, in erosion, and in damage to young trees.



### Recreation

Most of the forested lands in the Missouri Basin with important value for recreation are in federal or State ownership. However, many farm woodlots and shelterbelts have appreciable local values for picnicking and small game and bird hunting. Some other more extensive privately owned forest lands doubtless have considerable value for recreation, particularly hunting and fishing.

The 25,000 square miles of national forests along the western rim of the Missouri Basin, including the Bighorn Mountains and Black Hills, provide some of the finest opportunities for forest recreation to be found anywhere in the United States. These areas are mostly mountainous with hundreds of attractive lakes nestled among forested valleys and lofty, snow-capped peaks. Thousands of miles of small streams meander through the timber and open meadows to add to the scenic beauty and attractiveness of recreational use. Some forest lands are being kept in their natural condition for those who enjoy the wilderness.

The less spectacular forest areas in the Great Plains and the Ozark Highlands of Missouri provide interesting wooded country that is enjoyed by those who live short distances away. For example, people from large centers of population, such as St. Louis and Kansas City, Missouri, use the recreational facilities of the Mark Twain National Forest in the Ozark Highlands in all seasons of the year.

The recreation resources of the national forests in the Missouri Basin are accessible to some 7,000,000 local residents and millions of tourists. There are 329 camp and picnic areas which have been developed for public use. There are also 22 winter sports areas and 5 Government-owned organization camps. In addition, private individuals and organizations own 38 organization camps, 79 resorts, and 1,200 summer homes which are built under Federal permit. During 1947, the recreation areas of the national forests in the Missouri Basin received 1,900,000 visits. In addition, approximately 6,387,000 sightseers used national forest highways and roads primarily to enjoy the forest environment and scenery.

A survey was recently completed in South Dakota, Colorado, and part of Wyoming to ascertain the amount of private capital invested in recreation developments on the national forests. Private investments (resorts, organization camps, winter sports facilities, summer homes, cabin camps, etc.) totaled approximately \$4,500,000 and 400 persons are employed seasonally in operating these businesses. On private lands within the national forest boundaries, the investment in similar improvements was estimated at \$2,000,000 with 200 persons receiving seasonal employment.

The demand for recreation facilities on the national forests is increasing steadily. It now far exceeds the capacity of existing recreation areas which are limited by funds available for developing and administering recreation use. Adequate facilities for health and safety are not available



to cope with the increasing popularity of winter sports. Scattered hunting and fishing camps are without the simple improvements for sanitation and fire protection.

Three of the national parks bestride the Rocky Mountains and lie partly within the Missouri River drainage. These are Glacier, Yellowstone and Rocky Mountain. A fourth national park, Wind Cave, lies farther to the east, in southwestern South Dakota; the only national memorial park, Theodore Roosevelt, embraces two extensive samples of the North Dakota Badlands. There are also a number of national monuments of either historical or geological interest, as well as one much-visited national memorial, Mount Rushmore, in the Black Hills.

All of these areas are administered by the National Park Service of the Department of the Interior. The three parks in the Rockies offer camping, hiking, mountain climbing, fishing, and, like all the other parks in the system, exceptional "nature recreation." All contain extensive roadless wilderness areas. Wind Cave National Park, above ground, is notable for its bison and antelope. The national parks and forests offer different kinds of recreation and supplement each other in their attraction for people from all parts of the United States.

The Fort Peck dam and reservoir are attracting thousands of visitors to view the engineering feat and enjoy boating, fishing, and other forms of recreation. As other bodies of water are formed in the Great Plains, similar opportunities will be available to develop additional recreational uses.

### Wildlife

The forested areas of the Basin contain a substantial share of the country's big game. In the National forests and adjacent lands, big game is estimated at about 225,000 -- 75 percent deer and 15 percent elk. The remaining 10 percent include antelope, black bear, grizzly bear, moose, bighorn sheep, and mountain goats. These estimates represent 12 percent of the elk, 31 percent of the grizzly bear, 15 percent of the moose, 26 percent of the bighorn sheep, and 7 percent of the mountain goats reported for the 48 States.

Most of the native grouse species of North America are found in the Basin, ranging from the alpine-inhabiting ptarmigan to prairie chicken. Among other important native game birds are quail, mourning dove, and wild Turkey. The Hungarian and Chukar partridges have been widely introduced and the former is well established in several sections. The Chinese Pheasant, an exotic and highly prized game bird, has been particularly successful in farm areas and provides good hunting in nearly every state in the Basin. Ducks and other migratory waterfowl are found in limited numbers in the forested areas and in greater numbers in other parts of the Basin.

The headwaters of the Missouri River contain some of the finest sport fishing in the United States. For example, the national forests in the Basin have approximately 6,000 miles of fishing streams and 30,000 acres of lakes. Principal species are trout (cutthroat, rainbow, lochleven, and brook) and the famous Montana grayling. In the warmer waters of the Basin, bass, sunfish, perch, catfish, and rough fish are common and provide much fishing.

Statistics by states with territory in the Missouri Basin, indicate that some 990,000 state hunting licenses and 1,200,000 state fishing licenses were sold in the Basin in fiscal year ended June 30, 1948. An estimate for the national forests indicates that those lands alone were used by approximately half a million sportsmen. On an area sampled in Colorado and part of Wyoming, the hunters stayed an average of 4 days and the fishermen spent approximately 9 days. Statistics are not available on the fish "datch", but the kill of big game on forest areas in the Basin was estimated to be about 90,000.

## SECTION II

### PROBLEMS AND GOALS

#### ACCELERATED AGRICULTURAL PROGRAM REQUIRED

The Missouri River Basin is a national asset that is still awaiting full development. It is predominantly an agricultural area where production has not reached its full potentialities. Much remains to be done to find and to adopt those agricultural measures that will conserve and use the land and water resources most effectively.

The extremes in production and income and the resulting instability of population within the Basin, particularly in the Upper Watershed and Plains, have presented a challenge to the people of the nation ever since the area was opened to settlement less than a century ago. Recurring and unpredictable periods of drought have characterized the Plains portion of the Basin. A dry cycle apparently occurred between 1835 and 1865 and was followed by above-average rainfall. The period from 1886 to 1895 was one of disastrous drought.

The disastrous drought of the 1930's was especially severe in 1934 and 1936. But the 1940's have been a period of unparalleled prosperity for the Basin due to generally adequate rainfall and high wartime and post-war prices. However, unfavorable weather must be expected in the future. Local droughts usually occur every year in some part of the Plains.

A major problem of the Plains has been drought, crop failure, and wind erosion, but other parts of the Basin, and even the Plains, have suffered from floods. Intense rainstorms have often produced severe damage to watershed lands and damaging floods.

The Flood Control Act of 1944 by authorizing the Pick-Sloan Plan partially meets the challenge of protecting the Missouri Basin from the full impacts of disastrous drought and floods. Through the passage of this Act and through substantial investments already made to carry out this multi-billion dollar engineering development on the Missouri River and its tributaries, the nation has given concrete expression to a national policy of investment in Basin-wide resource development.

But comprehensive resource development cannot be attained without accelerating the agricultural program to complement and support the engineering phases. Plans cannot be made in terms of rivers alone. The rivers and watershed lands must be considered together.



But neither special authorization nor appropriation has yet been made to carry on the accelerated program essential to the comprehensible development of the watershed lands of the Basin.

Under present authorizations, programs of the U. S. Department of Agriculture must be carried out with essentially the same intensity throughout the nation. Under these nationwide authorizations effective contributions are being made, of course, to soil and water conservation, to forest and range conservation, and to the improvement of irrigation farming in the Basin. There is clear recognition, however, of the need for accelerating these programs to conserve and improve watershed lands; to build up and protect forest resources; to protect and develop the water resources; to enlarge and improve the farm land by irrigation and drainage; to reduce flood and sediment damage, and to support and balance the river development programs of other agencies in other ways.

### LAND USE OBJECTIVES

The long-range land use objectives for the Missouri Basin are consistent with long-range national agricultural policy as well as the regional interest of this important area.

The authorization and implementation of the Missouri River development program provided for under the Flood Control Act of 1944 is an expression of the wise national policy of developing the resources of all parts of the Nation.

This policy calls for effective measures to protect as well as utilize to the full these new investments in our resources. This can be accomplished through the improvement as well as the protection of the productivity of the rich agricultural resources of the Basin. This is in line with the "national policy of organized, sustained and realistic abundance" of the U. S. Department of Agriculture. 1/

Agricultural problems and goals are described in this report in terms of their significance to Basin-wide comprehensive development, and in terms of the size and scope of the jobs that need to be done. The inventory of needs as set forth here is based upon many years of experience, recorded observations, and research by the U. S. Department of

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1/ Programs to Effectuate a Long-Range Policy of Abundance, then Assistant Secretary of Agriculture Charles F. Brannan before House Committee on Agriculture and Subcommittee of Senate Committee on Agriculture and Forestry, October 6, 1947.

Agriculture, the Agricultural Experiment Stations and Extension Services in the 10 Missouri Basin States, and other State agricultural and forestry agencies. 2/

### STABILIZED AGRICULTURAL PRODUCTION

Agricultural production will be stabilized and increased in the Missouri Basin as the combined result of the accelerated program proposed in this document, increased irrigation construction by the Bureau of Reclamation, flood protection by levees constructed by the Army Engineers, and improved technology generally. Some of this increased production may encounter difficulty at times in finding markets as favorable as those during the war and immediately thereafter. But from the long-run view, the proper development of the resources of the Basin will benefit the Nation through food and fiber production fitted to national demand, stable supplies of forest products, a more stable basis for commercial and industrial development, and increased recreational opportunities.

Good farm incomes are essential to a strong business situation and, in turn, a healthy and prosperous business is dependent upon a prosperous and stable agriculture. No group stands to gain more than agriculture from an increase in industrial expansion within the Missouri Basin. Economic as well as social interdependence of rural and urban communities exists to a high degree.

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2/ Reference is made to a report submitted by the President of the Congress of the United States on February 10, 1937, under the title The Future of the Great Plains. In his letter of transmittal President Roosevelt wrote: "The report indicates clearly that the problem of the Great Plains is not merely one of relief of a courageous and energetic people who have been stricken by several years of drought during a period of economic depression. It is much more fundamental than that. Depression and drought have only accentuated a situation which has been long developing. The problem is one of arresting the decline of an agricultural economy not adapted to the climatic conditions because of lack of information and understanding at the time of settlement and of readjusting that economy in the light of later experience and of scientific information now available." (H.D. 144, 75th Congress, 1st Session.) It is noted, therefore, that the agricultural problems of the Great Plains have been brought to the attention of the Congress previously.



Agricultural production in the decade immediately ahead must make adjustments for the heavy drain placed on the land by intensive cropping. Those responsible for new land to be brought into production through new irrigation and new drainage programs will need to take account of changing demands. From both the standpoint of conservation and the necessary adjustment of production to demand, a reduction of grain crops and some intertilled crops will be needed. Greater emphasis will need to be given to sod crops, high quality hays, and improved rotation pastures, together with the livestock needed for proper utilization of increased forage.

#### CONSERVATION ON FARMS AND RANCHES

Conservation needs in their varying aspects of erosion, water losses, irrigation and drainage, and improved management of soils, crops, range, and woodland are common problems for nearly all farms and ranches in the Missouri Basin. Most of them either contribute flood water and sediment or bear the brunt of their downstream damage. In order to help land owners and operators to deal adequately with these problems, the program must provide for the effective use of land and water through desirable combinations of conservation practices and measures which will maintain and improve productive capacity.

Changes in land use are desirable on some 23 or 24 million acres, especially in areas of critical erosion. At least 10 million acres of crop land, in a total of 113 million acres in the Basin, should be returned to grass. Most of this is eroding, dry farm land and, by far the larger part, was used to grow wheat and flax in and after the Second World War.

In encouraging the adoption of conservation farming and ranching, the program must emphasize the need for a higher proportion of land in rotation hay and pasture and a corresponding decrease in intertilled and close-growing crops. Livestock use should be adjusted to range conditions. The need exists to reduce water losses arising from reservoir sedimentation, faulty canals and ditches, improper irrigation and drainage, and non-productive vegetation.

One of the cardinal principles on which the program is founded is that conservation and use of land and water must be dealt with as an inseparable problem. The program also recognizes that farmers and ranchers have the capacity to solve conservation problems, in spite of their complexity, if a reasonable amount of public assistance is provided. Farmers and ranchers are expected to assume primary local responsibility for their conservation programs and, if possible, undertake them through continuous and effective group action. Organized activities are, moreover, a suitable channel through which public assistance can reach farmers and ranchers.



Shelterbelts and windbreaks need to be greatly expanded in parts of the Missouri Basin. The numerous benefits of a shelterbelt program include protection in all seasons to homes, livestock, gardens, orchards and fields, soil and water conservation, improved and protected highways in all seasons, added protection to wildlife and beauty to the landscape, and an increased supply of fuelwood, post, and other timber products.

#### CONSERVATION AND USE OF THE FOREST RESOURCE

The forest lands of the Basin, which now supply less than one-fifth of the lumber and other wood products used in the area, are capable of yielding continually more than double the present output.

The timber resource objective is to place and keep all commercial forest lands in condition for maximum sustained yield production of lumber and wood products consistent with the requirements of other forest land uses. This requires a high degree of efficiency in fire control on all forest lands. The application of good management is the key to high levels of timber production. Public acquisition of forest lands, including areas lacking adequate management as well as those necessary to the economic management of public lands, is involved in attaining the desirable objective. Rebuilding of run-down hardwood forests and replanting of poorly stocked and denuded areas are essential. Road construction is required to open presently inaccessible areas for cutting in the western national forests. The goal also implies creating and expanding markets for little-used species and sizes. Its attainment should provide a 400 to 500 percent increase in employment in harvesting timber and manufacturing lumber and other wood products.

The forest ranges in the national forests and adjacent woodlands are of vital importance to local livestock enterprises as a source of feed and are also valuable for watershed management purposes in aid of flood control and to assure water supplies for irrigation and other uses.

Present deteriorated conditions on some of the western ranges in the national forests, the grazing districts and other public lands as well as private lands show the need for extensive treatment to increase forage production and to check erosion. In many areas signs of range deterioration are not generally recognized, and the serious damage to the productive capacity of the land is not accepted even by many of those most closely in contact with this damage.

Poor and depleted conditions are prevalent on perhaps 1 million acres of forest range below the national forest boundaries in Colorado and Wyoming. These lands are now used mainly for livestock grazing, but they have a higher value for watershed protection. In some areas, watershed damage from overgrazing is augmenting periodic flood damages to local communities which already exceed the tax revenue that the lands can pay.

Similar problems resulting from overgrazing exist on the open range lands of the western plains and the upper watershed, including those administered by the Department of Interior.

Throughout the hardwood forests of the eastern part of the Basin, the cream of the commercial species has been cut with insufficient attention to their replacement. Overcutting, overgrazing, burning, and in some instances unwise land clearing have greatly reduced the forested area and have impaired the quality and productivity. Stands of high-quality saw-timber of desirable species have been replaced by scrubby stands largely of inferior species. Forest depletion has meant a loss of basic wealth. Markets for local forest products and the returns from labor have been depressed.

Heavy losses have occurred from fire, insects, and diseases. In Montana, it has been estimated that 3 billion board feet of lodgepole pine has been killed by bark beetles during the past 30 years. In addition, more than 2 billion board feet of ponderosa pine, Douglas fir, Engelmann spruce, alpine fir and white-bark pine have also been destroyed. In the eastern limits of the Basin, a wide variety of leaf feeders and wood borers attack both native and planted trees. Although serious outbreaks are few, recurrent defoliation in combination with drought is credited with killing a sizable percentage of the trees in some localities. The chief losses from such insects, however, are reductions in rate of growth and loss of quality.

Oak wilt is a serious threat to the hardwood forests, while diseases that cause losses in timber volume and quality are prevalent in softwood stands (ponderosa pine, Douglas fir, lodgepole pine, etc.) which have passed maturity.

Damage from fire cannot be readily appraised. Even though trees survive, they are frequently scarred or their resistance to attack by insects and diseases is lowered. Damage to timber resources in Montana, Wyoming, and Colorado was estimated at \$66,000 for 1946; in Missouri (entire State), \$231,000.

The management of State and privately owned forest lands leaves much to be desired. An expansion of the cooperative federal-State programs in providing technical education and service to small woodland operators is needed.

The rehabilitation of privately owned forest lands is handicapped by the lack of trees for planting because of the inadequacy of existing nurseries which supply planting stock for this purpose.



## REDUCTION OF FLOOD AND SEDIMENT DAMAGES

One of the goals of the agricultural program is to reduce damages caused by floodwater and to prevent erosion thus reducing the amount of sediment damage. Fortunately the conservation measures and practices recommended for the lands of the Basin result not only in conserving the land and increasing production, but also in substantial benefits from reducing floodwater and sediment damages.

In the Basin as a whole, a large proportion of the reduction in damage from floodwater and sediment will be brought about by the conservation measures to be applied to the crop, range, and forest lands of the watershed. The practices and measures necessary to conserve the soil and promote a stable and prosperous agriculture will, therefore, constitute the principal means of carrying out the Department's responsibilities under the flood control acts. However, in many cases additional benefits can be secured by measures and works not ordinarily constructed by individual farmers. The supporting program of stabilizing measures for small watercourses will complete and round out the total program in aid of flood control.

## ENHANCEMENT OF WILDLIFE AND RECREATION

The best land use for several million acres of the land in the Basin will be for recreation and the production of wildlife, while the principal of multiple land uses will result elsewhere in increased recreational uses and the wider distribution of the optimum in wildlife.

The inter-relationship of wildlife production with the management of other land resources is in need of greater attention. Fish and wildlife are more than an incidental resource, and adequate provision must be made for suitable environment. It is an objective of this program, therefore, to integrate wildlife habitat needs with timber cutting, grazing, and other land uses so that each locality will make its full contribution of wildlife along with other land resources.

The recreational use of forest lands is steadily expanding. The trend of mounting use is expected to continue over the next 30 years. Recreational use of national forests areas in the Basin is expected to increase by 130 percent in Montana, 300 percent in Colorado and part of Wyoming, and 500 percent in Missouri.

The problems of providing and maintaining necessary facilities and services to handle the persistent expansion of recreation use are increasing year by year. This is particularly serious in the West, where many cities obtain domestic water and recreation from the same watershed. It is entirely practicable to plan such dual use, but it is essential that proper sanitary and fire protection facilities be installed to protect the water supply and the watershed.



Timely planning and development of recreational facilities on sound principles of good land management is essential to meet these growing requirements. An urgent aspect is the restoration of over-used public facilities to full usefulness and the expansion of facilities into new areas which will distribute the pressure of recreational uses. As most of the forest lands with recreation values are in public ownership, a great deal of the responsibilities for additional development will fall upon public agencies. Their acquisition of tracts with high recreation value, highway screening strips, parking areas, and wilderness land is desirable. However, private individuals and organizations should not only develop recreation facilities but also take part in cooperative programs with public agencies where mutual interests can be advanced.

#### HEADWATER PROTECTION

Steep headwater areas are best protected by forests in good, healthy condition. The presence of good forest cover — trees, shrubs, grass, and litter — provides protection and stability to the soil. It is protected from deep freezing and the resulting porous character enables the soil readily to absorb and detain the water from rains and melting snow. Good forests hold down the amount of runoff and reduce the height and frequency of destructive flows. Water that moves through the forest soil returns to the surface in natural springs and stream channels or collects underground where it may be made available by pumping. The clear sustained flows of well-forested watersheds are the direct result of the natural balance between forests and the soil.

In contrast, the soil loses its porous structure and much of its absorptive capacity when the ground is bare or when the mulch is destroyed, as by fire. Similar unfavorable conditions develop on over-grazed forest ranges when the ground cover is too closely clipped and the surface is compacted by livestock. When the surface soil is thus altered and exposed, runoff gains in volume and speed. Organic material is oxidized and the top soil, containing the rich, spongy humus, is carried away. Heavy rains compact the soil and seal the surface against infiltration. The loss of vegetation also permits soil freezing and thus cuts down the percolation of snow-water. All this means impoverishment of the land and impairment of the quality and usefulness of the water. Under such conditions, fluctuations in stream flow are magnified. Streams rise swiftly to flood stages with each rain only to drop to very low yields or even to disappear temporarily. And because less water gets into the soil, less water replenishes the underground basins.

Furthermore, the absence of cover invites erosion with resulting sedimentation damage. The loss of the porous surface soil exposes the denser and usually much more erosive subsoil. In only a few years erosion damages may become so serious that the adverse effects will be felt for decades.

The goal in fire control for the mountainous forest lands in the western part of the Basin is to keep the average annual burn damage within one-tenth of 1 percent of the protection unit. For the lands which are managed for the protection of high watershed values, a protection unit may be as small as 100,000 acres. On other forest lands, the protection unit may be a million acres. In the eastern broadleaf forest of Missouri, much of which is still without organized protection, the goal for State and private forest lands is five-tenths of 1 percent. Fire protection on the national forests is approaching one-tenth of 1 percent of the total land area protected, while on other forest lands the proportion of burned area is considerably larger.

In the national forests a high degree of fire protection has been maintained. In contrast fire damage on some private forest lands has been much higher. States and the U. S. Department of Agriculture are authorized to cooperate with the State forestry agencies in protecting State and privately owned lands from fire. Federal cooperation is now being used in Montana, Colorado, South Dakota, Minnesota, and parts of Iowa and Missouri. All forested areas in the Basin are not yet under protection and present standards of protection are not adequate.

Fire losses are not confined to the destruction of timber; recreational opportunities, fish and wildlife, and feed for livestock are also damaged. Moreover, the soil-protecting litter of twigs and leaves on the forest floor and the organic material in the soil itself are destroyed.

In parts of the Rocky Mountain area, land use practices have accelerated damages from soil erosion and floods. On the slopes subject to violent thunderstorms, some soils are highly erodible and easily damaged if unprotected by vegetative cover. Here fire, livestock and big game grazing, mining operations, logging, and road building have contributed to extensive sheet and gully erosion, accelerated and concentrated runoff, instability of stream channels, heavy silt movement, and more frequent and larger floods. Erosion generally has not been so widespread at the higher elevations where the land use is less intensive, but in localized areas erosion is prevalent and frequently serious.

Many of the valley bottoms throughout the Basin are wooded, and trees occupy sandbars and islands in the larger rivers. Although the woodland along the streams is generally beneficial in preventing bank-cutting and erosion, much of that growing in the bottoms proper and on adjacent areas with a high water table may be wasteful of water.

In the Ozark Highlands, watershed conditions have been seriously impaired by a long history of repeated timber cutting, burning, and overgrazing. For the most part the forest has been reduced to a scrubby growth with little if any accumulation of litter on the ground.



As a result, runoff is excessive and streamflow unstable. In this part of the Basin flood damage to valley lands is a major problem. On the other hand, hydroelectric power installations frequently suffer from inadequate water supply during dry seasons. Seasonal water shortages also affect a large local population which depends upon wells and small reservoirs.

Watershed management has for a goal the reduction of flood and sediment damage. While land and its cover is unable to cope completely with conditions which cause large floods, good land management, with minor upstream engineering works, can do much to prevent damage in smaller tributaries and can aid substantially in reducing flood flows in larger channels. Good watershed management can also contribute significantly to the protection and efficiency of storage reservoirs through reducing the rate of erosion and consequent reservoir sedimentation. High quality water for domestic and all other forms of use is another valuable product.

#### DRAINAGE OF FARM LAND

Adequate drainage is essential to agricultural production on considerable areas of land in the Missouri Basin. Drainage of lands suffering from too much water is equally as important to the general agricultural welfare as the irrigation of lands with too little water. Rehabilitation of drainage systems already installed but not functioning adequately, as well as the construction of new drainage systems, is required. Adequate drainage systems should be planned and installed concurrently with the planning and installation of levees to protect river bottom lands from overflow.

#### INCORPORATION OF IRRIGATION IN BASIN AGRICULTURE

New irrigation of 6 million acres must be fitted into the Basin's agricultural pattern of 113 million acres of crop land and 175 million acres of range and pasture. This is a new and large scale task, especially where dryland farms are now occupied by farm families.

In much of the Missouri Basin the value of water as a production factor changes from year to year -- from years of adequate rainfall, to years with short drought periods, and, finally, to the extreme years of almost complete drought. New farming operations must be set up to use climatic advantages of the better years and yet make irrigation a continuous, integral part of farm operations. The benefit of irrigation in much of the Basin, therefore, comes both from increases in production and from the prospect of more stabilized production. This set of conditions means that successful irrigation in the subhumid areas will rest upon a different set of principles than those found in distinctly arid sections.



Luxuriant irrigated crops draw more heavily on the reserves of soil fertility than the less bountiful yields of unirrigated land. Soil fertility and physical soil properties favorable to irrigation are likely to be impaired unless farm management is adjusted to the new conditions. Research in irrigation agriculture needs to be fortified and extended to reach the subhumid sections now proposed for irrigation. Present information for soils of the central plains is inadequate as a guide for irrigation development there, and considerable land already has been permanently damaged by irrigating the wrong soils and by poor management on soils fairly well suited to irrigation.

Successful irrigation experiences and techniques in similar climatic areas will be evaluated and interpreted for new settlers. Each area in which irrigation is to be introduced needs investigation to determine the differences in the use arising from the fact that the project is surrounded by either grazing or wheat lands.

Opening newly irrigated land carries with it problems in scope and intensity comparable to those involved in establishing brand new settlements. These questions range from general determinations of the value of various systems of farm management to the individual problems of the new irrigation farmer in making the investments required by a new and unfamiliar type of farming. The solutions will determine not only how soon but also by how much the new irrigation will improve the agricultural productivity and stability of the Basin.

The opportunities irrigation presents in partly or wholly irrigated farms and their integration with upland crops and livestock require the determination of a variety of farm management problems. The adaptation of lands to new and untried crops, water requirements, methods and techniques of water application, responses of different soils to irrigation need systematic study. Technical help, assistance, and direct aids such as payments, equipment, usage, and materials, and a program of education are essential if farmers are to make the transition to irrigation farming, while additional investments in new equipment and buildings will require adequate credit. New crops will need new market outlets and marketing facilities.

#### ADJUSTMENTS OF FARMS AND COMMUNITIES

The programs and activities now underway, or contemplated, in the Missouri Basin will eventually affect all farm families in it, but special adjustment problems will confront 50,000 to 60,000 families immediately involved in irrigation and flood control programs. Inundation of reservoir lands will require the relocation of about 4,000 families. About 19,000 existing dry farms will be irrigated and will need to dispose of excess land on which about 19,000 new farms may be established. The levee systems will provide flood protection to 13,000 farms which will need reorganized farming

systems to take advantage of the reduced flood hazards. These adjustments will take place over a period of years and in most cases with enough advance notice so that the changes can be planned in an orderly manner with the aid of educational, technical, and financial assistance, and credit.

Adjustments resulting from development of reservoirs not only involve hardships to those who must move, but also may disrupt community services and facilities and local economies. Proper evaluation of these factors in selecting alternative sites is essential in planning the reservoir systems. Once the reservoir is selected, the community is involved not only with problems of relocating people but also with problems of dislocation and disruption of schools, roads, markets, churches, and other similar community services. There is a responsibility to render assistance in planning and making these adjustments.

### IMPROVED FARMING AND FARM LIVING

Good crops and profitable prices have made the Basin a land of plenty in recent years, but many problems remain unsolved and many needs unfilled. In spite of the favorable years, farmers require reserves and plans to protect themselves against possible drought. They must follow proper land use principles and install conservation practices to protect their land from both drought and intense rains. Supplemental irrigation can help. The additional irrigation, amounting to 5 or 6 million acres, can contribute to the stability of agricultural communities when they are developed. But most of the crop land will always be farmed without benefit of irrigation and will have to depend on farming around the weather. The search for better land and water management practices, improved conservation techniques, and better adapted varieties of crops and forage is far from finished.

This agricultural program is designed to provide farmers with improved technology that safeguards farm business stability. Another imperative goal is the credit that tenants need to become landowners in their own right and operators to live through crop failures. In cooperation with the Land-Grant Colleges and Universities, the program will assure farmers year-around educational opportunities with full-time, well-trained representatives to bring the latest reliable information on new and improved methods of making a profitable and comfortable living. Reliable market and production information will be provided, as well as a program of research which lays a basin-wide foundation for agricultural improvement. The State Agricultural Experiment Stations will cooperate in this program and coordinate their research with it. Basic research in soils, plant breeding, animal breeding and feeding, insect control, agricultural engineering, forestry, and agricultural economics is often unspectacular, but, without it, this Nation could not have achieved its increase of 50 percent in total agricultural production since World War I.



The Missouri Basin agricultural program is directed toward improvement of farm life and the welfare of rural communities. Since the days of the first farms and farm homes in the Basin, agricultural services have expanded to cover a wide field not only with respect to technology but also in programs of service and research to promote greater security and more convenient and comfortable living for Basin farmers and their families.

The sparse population of a large part of the Basin creates difficulties in furnishing adequate rural community services. Roads, schools, health facilities, rural electric lines, and other services are expensive in thinly settled areas. Another problem is the few employment opportunities for the rural youth within the area. About half these farm boys and girls find opportunity only by migrating from the farm. In the past many have left the Basin. Industry and trade in the Basin must expand to balance the agricultural resources and to furnish a more stable population and employment pattern.

If the Missouri Basin is to realize its greatest potential, farm homes and rural community life must be made attractive and satisfying. This means better housing with available rural electrification, convenient domestic water supply, and other home improvements and equipment comparable to urban standards. Rural youth will be attracted by nothing less. Improved health services in the form of hospitals, clinics, good doctors, and dentists also are essential to the rural community as well as improved roads, schools, and recreational facilities. All these are important in maintaining farm families with pride and determination to make fullest use of the investments being made in the Missouri Basin Development Program.



### SECTION III

#### RECOMMENDED AGRICULTURAL PROGRAM FOR THE MISSOURI RIVER BASIN

In this section there is set forth a multiple-purpose and unified agricultural program for the Missouri River Basin. This program embraces the agricultural measures and activities required for the full and efficient development, utilization, and conservation of the land resources of the Basin. It is designed to balance, complement, and support programs and works for flood control, water supply development, water power generation, navigation, and like purposes, and to be carried out concurrently with them. It contemplates the acceleration of a number of programs and activities now being carried out in the Basin by the U. S. Department of Agriculture, the Land-Grant colleges and Universities, and other public agencies. It also provides for the effective integration and coordination of these programs and activities.

This section has been divided into the following chapters:

- A Program of Conservation and Improvement Measures for Grassland and Cropland.
- A Program for Forest and Forest Range Lands.
- A Program of Stabilizing Measures for Small Watercourses.
- A Program in Aid of Irrigation.
- A Program to Improve Drainage on Agricultural Lands.
- A Program of Soil Surveys and Land Classification.
- A Program of Research and Investigations.
- A Program of Extension Education.
- A Supporting Credit Program.
- Rural Electrification in the Missouri Basin.

It is recommended that the multiple-purpose and unified agricultural program as contained in this report be approved. In general, the work recommended in this report will be carried out in accordance with the provisions of existing laws relating to the activities of the Department of Agriculture.

In some instances, it is necessary that these authorities be expanded or modified to adapt them to the program set out herein. For example, the program outlined in "A Supporting Program of Credit" is an expansion of

existing authority tailored to meet the needs of the region. In other instances, as, for example, in "A Program of Extension Education" and "A Program of Conservation and Improvement Measures for Grassland and Cropland," it is necessary to remove certain limitations as to the allotment of funds.

While approval is requested of the entire program set forth in the section entitled "A Program of Stabilizing Measures for Small Water-courses," there is requested at this time an authorization for appropriation for the initial stage of the program for the installation of such stabilization measures.

The approval of this report conferring authority on the Secretary to carry out the recommended program shall not be construed to limit the exercise of powers heretofore or hereafter conferred upon him or any agency of the U. S. Department of Agriculture to carry out any of the measures described herein or any other measures, but such authority shall be supplemental to the powers and authority conferred upon the Secretary or any agency of the Department under existing law.

In furtherance of this program it is recommended that the Secretary of Agriculture be authorized to make further surveys and investigations of any part of the Missouri River Basin to determine its agricultural resources, potentialities, problems and needs and to prepare and submit to the Congress such reports and recommendations with respect thereto as he may deem appropriate.

It is recommended that the Secretary of Agriculture be authorized to make such modifications or substitutions of the measures described herein as may be deemed advisable due to changed physical or economic conditions or improved techniques whenever he determines that such action will be in furtherance of the objectives of the recommended program.

It is contemplated that the Secretary of the Interior will carry out that part of the program proposed for installation of measures on lands under the administration of the Department of the Interior.



PROGRAM OF CONSERVATION AND IMPROVEMENT MEASURES  
FOR GRASSLAND AND CROPLAND

The phases of the program covered in this chapter deal primarily with the individually owned and operated farms and ranches in the Basin. Lands in public ownership are included only to the extent that they are under lease and form a part of an individual farm or ranch.

Conservation and management of land resources in the Missouri Basin is essentially a task for the Basin's 582,000 farmers and ranchers. They need a specific program that gives them the help they require, and, at the same time, encourages them to get on with the work. Part of the job rests, of course, with those public agencies whose responsibility it is to administer public forests and other public lands.

The use the individual makes of his land -- whether or not he conserves and protects its productivity -- is determined by his knowledge, his skills, his experience, and his attitudes, plus many influences outside his own choice. National and Basin-wide land policies and programs must serve as his allies in gaining the goal of conservation and good land use.

As set forth in this agricultural program, government has a major function to take active steps to preserve and protect the land, water, and forest resources of this important river basin by working with the farmers and ranchers to provide technical information and other aids for the conservation and management of crop lands, range lands, and forests, to help groups of farmers organize the most effective water management and land management in entire watersheds, and to make provision for equitable sharing of the costs between the individual land owner and the public. The fullest uses of public lands of the Basin consistent with sound conservation and long-time benefits to the greatest number of people is another function of government set forth in this program.

The rate of progress in establishing essential soil and water conservation and management measures will be slow in relation to the urgent need to conserve irreplaceable land resource. Only on the national forests and other publicly owned land can government determine the rate at which it shall apply conservation measures. How rapidly and how completely a conservation program can be installed on the privately owned land, 78 percent of the Basin's area, rests ultimately with 582,000 farmers and thousands of land owners.

Much has already been done to establish conservation practices on the lands of the Missouri Basin, but much more remains to be done. During the 15 years since organized national programs have permitted direct work with farmers and ranchers, fully 75 percent of the farms and ranches have participated in initiating some conservation practices. However, a relatively small percent of the lands of the Basin are now estimated to be under adequate conservation management.



Some phases of conservation were retarded during the war years, but an enormous acceleration is now possible and is badly needed. The program proposed in this report would result in a great increase in the rate of applying conservation measures.

In this accelerated program, provision is made to work with each farmer and rancher in developing and applying conservation practices and adopting the combination of land use measures each farm and ranch needs. The program likewise proposes to obtain appropriate conservation measures on specified problem areas or small watersheds. This effort will be applied selectively by concentrating first in the most critical areas and by expanding as rapidly as possible to all problem areas of the Basin.

The public will share with private land owners and operators the costs of economically sound conservation measures on cropland, grassland, and forests. Provisions are made in this plan for assistance in the form of direct aids, technical services, education and information, credit, research, and other aids or assistance in the form of materials, equipment, and services. Farmers and ranchers will provide a fair proportion of the cost of materials and equipment, and, in addition, bear costs of seed bed preparation, seeding, spreading of lime and fertilizer, maintenance of structures, labor required for application, and other costs normally involved in the installation and maintenance of conservation practices.

Public assistance will be held to a small percentage of the cost of feasible practices in general use in certain areas, and the aid will not exceed the amount needed to gain similar applications on all farms. Certain practices, however, need to be introduced and demonstrated, especially some with benefits other than those directly accruing to the treated land. In these instances, the public will bear a larger proportion of the cost. A wide degree of flexibility must be maintained in the public assistance in order to foster conservation practices in the kinds and amounts necessary to fit the wide range of land conditions from one end of the Basin to the other.

The conservation practices and land use measures recommended for privately-owned and public lands are described here in terms of their estimated scope and the public's share of the cost. In planning for their application year by year and area by area, the Secretary of Agriculture will be guided by economic conditions, improvements in technology, and other considerations essential to a sound program.

#### MEASURES FOR GRASSLAND

The privately owned and operated range and pasture in the Basin amounts to approximately 157.5 million acres. These lands are parts of operating units which vary from small farms in the east to large ranches in the west. The eastern pastures are intermingled with cropland and are used primarily for supplemental forage. The western ranges are often

intermingled with large areas of public range or forest lands. Integrated programs of management will be applied to public lands which adjoin privately-owned areas.

The proposed conservation practices are those that will (1) contribute directly to the establishment and maintenance of vegetative cover, (2) permit management and use of forage crops on a sustained or improved yield basis, and (3) reduce erosion where natural cover is inadequate.

The application of these measures will be accelerated by additional technical assistance in the form of management plans worked out with ranchers and farmers and by providing incentive payments, conservation materials, and services.

### Practices to Establish or Maintain Grass Cover

#### Reseeding ranges and pastures

Reseeding approximately 17.5 million acres of depleted or denuded range and pasture land with adapted varieties of legumes and grasses is recommended. This acreage includes areas where natural methods are incapable of restoring cover, unpalatable weeds and browse are predominant, and accelerated erosion has depleted the topsoil to the extent that vegetation must be replaced. Most reseeding will require proper seed bed preparation and improved planting methods. Careful management practices will be necessary until grass is fully established.

#### Range and pasture management

Changes and improvements in management methods are recommended for approximately 117.3 million acres of grassland. Management involves adjustment of livestock numbers to give the grass a better chance to grow and, where a substantial proportion of the desirable forage plants is still present, to reseed itself. The cost of restoring grassland with native adapted varieties is often much less than the cost of reseeding. The cover and forage is in many cases far superior to that of introduced or domestic varieties.

This practice will necessitate the adjustment of livestock numbers to the capacity of each grazing unit. Proper management may require total protection of problem areas, rotation and deferred grazing, changes in seasons of use, and, in extreme cases, changes in the class of livestock. These practices will become a part of the conservation program to be used with other practices on each ranch and farm.



### Deferred grazing

Deferred grazing is recommended on approximately 7.7 million acres of summer range or pasture land principally in Kansas, Nebraska, and South Dakota. This practice protects and improves grasslands depleted through grazing in the growing and seed development period. The periodic use of this practice will permit complete forage growth to build up vitality and soil-binding root growth, to produce adequate seed for natural reseeding, and to provide moisture-conserving cover which will reduce runoff and protect the soil.

## Practices to Promote Better Distribution of Livestock and Protect Grasslands

### Livestock watering facilities

Additional livestock watering facilities are needed to permit proper distribution of grazing. They are essential before proper management methods may be adopted. Properly spaced watering places reduce the concentration of grazing and encourage more uniform use of grassland. They promote optimum use of forage resources and eliminate serious depletion along running streams and large flowing springs. Proper grazing management and proper rates of stocking are essential to make improved watering facilities fully effective. Their distribution, as well as their types, are governed by the topography, location, size, and management methods of farms or ranches.

Assistance is recommended to help farmers and ranchers expand the rate of constructing ponds, developing springs and seeps, drilling or digging wells, and installing supplemental storage tanks and pipe lines.

Ponds.--It is recommended that 407,000 additional ponds be constructed where they are the most practical and feasible method of providing livestock water. In the Lower Basin and Eastern Plains, ponds have demonstrated their value as a primary source of water in diversified farming. Available water enables many farmers to establish permanent pasture on areas that are unsuited to cultivated crops.

Larger ponds have proven better because they provide livestock water for longer periods. The water supply in these larger structures can be assured even though the normal evaporation loss is high in certain areas. In extreme drought, they have been known to provide adequate water for two grazing seasons. Some ponds will need linings to be effective. These ponds, added to the 250,000 reservoirs already constructed under programs of the U. S. Department of Agriculture, will have a storage capacity estimated conservatively at more than 4 million acre-feet. These structures are adaptable to certain areas in all States in the Basin.



Springs and seeps.--It is recommended that approximately 32,700 springs and seeps be developed. Springs and seeps generally supply the most economical livestock water; therefore, all feasible sources should be developed. They are generally found in the more rugged parts of the Basin where geological changes have brought water-bearing strata to the surface. .

Wells.--It is recommended that approximately 78,000 additional wells be provided on the larger ranches in the arid and semiarid areas. Public assistance is recommended only when development costs are reasonable and other suitable facilities are impracticable. Wells at farm or ranch headquarters are not included in this recommendation since they contribute little to the distribution of livestock and conservation of grazing land.

Supplemental water storage at wells or springs.--It is recommended that approximately 21,000 storage structures be provided in the arid and semiarid range areas. These installations will furnish an adequate supply of water available for use during the entire grazing season. Seasonal flowing springs and wells equipped with windmills are more effective if the water is stored for use when proper management dictates. Stored water can be piped to locations where other water facilities cannot be brought into use. These are recommended as a contributing measure to conservation of water and range lands.

Pipe lines.--It is recommended that approximately 7.7 million linear feet of pipe lines be installed to carry available livestock water to areas without other water sources. Pipe lines can furnish water from a central source to two or more pastures in a rotational pasture system.

Lining reservoirs.--It is recommended that approximately 28,000 ponds be lined to prevent seepage. Public assistance should be limited to those structures where unforeseen seepage develops. Bentonite, oil- or asphalt-treated soil, and impervious clay are most commonly used for this purpose. This practice will prevent water losses due to seepage and will make the ponds effective for water storage. The number of ponds that need to be lined is small in comparison with the total constructed.

## Fences

Proper grazing management requires 65,000 miles of fences to control and distribute livestock. These fences are needed to prevent trespassing on the large open ranges and to divide ranges into pastures which will permit rotational grazing and promote proper range use. In some instances, denuded or badly eroded areas and sand dunes must be protected by excluding all livestock as a means of reestablishing natural vegetation. New seedings also need protective fencing. Public assistance should be limited to fences essential to improved grassland management and not include replacements or fences constructed for crop protection.

### Livestock trails

The construction of approximately 2,000 miles of livestock trails is recommended to obtain better distribution of livestock. Trails are used to open up inaccessible areas of grass and water. They also are effective in correcting erosion hazards which have developed from livestock trailing long distances through natural passes to forage or water.

### Fire Guards

Approximately 166,000 miles of fire guards are recommended for construction along roads, highways, railroad rights-of-way, ridges, and other strategic lines. The problem of protecting grazing lands from fire has increased materially as the result of improved management methods which encourage the accumulation of crop residues for soil cover. This increases the accumulation of inflammable materials. Recommended fire guards expose the bare mineral soil for a minimum width of 10 feet by cultivation or the use of chemicals or oil in special areas. This practice should be extended to prevent the loss of conservation measures by fires.

### Control of Rodents

A program of eradication and control of prairie dogs and ground squirrels is recommended on approximately 10.3 million heavily infested acres. The destruction of forage by rodents seriously retards any conservation program. In areas of serious infestation, the native vegetation is sometimes completely destroyed as the rodents eat both the tops and roots of forage plants.

### Control of Insects

A control program is recommended to reduce the hazard of grasshoppers and Mormon crickets. Approximately 2.1 million acres are seriously infested. In favorable seasons, these infestations will spread over a large portion of the Basin and destroy both grassland cover and crops.

### Removal of Competitive and Poisonous Plants

The removal of undesirable, unpalatable, and poisonous weeds and brush from approximately 16.2 million infested acres is recommended. Many times this condition has resulted from the destruction of natural vegetation by drought or misuse. The competition for moisture prevents the area from producing an adequate cover to control wind or water erosion. In addition, the economic value of the land is impaired. The removal of these plants will allow natural grass to become reestablished and enable the range to return to its normal productive capacity. The removal of these plants can be accomplished by mechanical methods such as railing, mowing, and grubbing and by the use of chemicals.



### Supplemental Erosion Control Measures

In areas of accelerated wind or water erosion, mechanical control measures are sometimes required. These measures generally are temporary and serve to control erosion until gullies or other eroded areas can heal with natural revegetation. The recommended practices are applicable to grassland and include water-spreading structures and contour furrows or pitting. Other practices, such as the establishment of waterways and outlets, roadside and streambank erosion control, and erosion control structures are among the recommended practices applicable to either crop or grassland.

Contour furrows or pitting.—It is recommended that contour furrows or pits be installed on approximately 5.2 million acres of grassland. This practice is needed mainly on grassland areas in the Upper Watershed and Western Plains where active water erosion must be controlled before a satisfactory vegetative cover can be established. On the gentle slopes, contour furrows have proven successful in reducing flood waters and increasing grass production.

Water-spreading practices.—It is recommended that ditches, dikes, terraces, and dams be employed on approximately 2.3 million acres of range lands to spread surplus flood waters. These supplemental irrigation systems increase the quality and quantity of forage. Generally the structures are placed in dry washes and arroyos where flash floods and spring runoff cause active erosion. These structures reduce the velocity of flood water, check erosion in the draws or arroyos, spread the water over dry grassland, and increase the yields of grass and hay.

### Summary of Measures for Grassland

The quantities and costs of the measures recommended for grasslands are summarized in table 15.



Table 15.--Measures Primarily for Grassland

Conservation or Land Use Measures	Unit	Estimated Needs	Cost <sup>1/</sup>
		Thousands	Thousand Dollars
A. Establishment or Maintenance of Cover			
1. Reseeding Ranges or Pastures	Acres	17,413	161,908
2. Range and Pasture Management	Acres	117,320	51,259
3. Deferred Grazing	Acres	7,763	4,797
B. Distribution of Livestock and Protection			
1. Watering Facilities			
a. Ponds	No.	407	404,018
b. Springs and Seeps	No.	33	16,631
c. Wells	No.	78	155,013
d. Water Storage	No.	21	14,415
e. Pipe Lines	Lin.Ft.	7,657	15,903
f. Lining Reservoirs	No.	28	3,668
2. Fences	Miles	65	66,418
3. Trails	Miles	2	995
4. Fire Guards	Miles	166	5,238
5. Control of Rodents	Acres	10,354	5,310
6. Control of Insects	Acres	2,124	2,073
7. Control of Weeds and Brush	Acres	16,212	88,574
C. Erosion Control Measures			
1. Contour Furrows and Pitting	Acres	5,251	24,937
2. Water Spreading	Acres	2,382	78,869
Total			1,100,026

<sup>1/</sup>Estimated total cost of installation or application.

## MEASURES FOR CROPLAND

The goal in conservation of crop lands is inseparable from the goal of profitable production. The production efficiency of thousands of farms can be increased through maintaining grass and legumes on sloping land endangered by erosion in intertilled crops. To make use of more hay and forage means that more farm operators must have skills with livestock and capital for breeding stock, fences, and buildings. Thus a pattern of new practices, skills, and resources is required to attain the indivisible goals of conservation and profitable production.

The program recommended for the Missouri Basin's 113 million acres of cropland will encourage and assist farmers to put the land to its best uses. Some land now used for crops will be used for pasture or for woods. Adapted crop varieties, improved production methods, rotations, insect and disease control, fertilizers, and lime all have their place in the conservation measures. Experience has shown that erosion cannot be controlled on some lands by good cropping practices alone. It will require concurrent use of terraces which in turn require terrace outlets, of gully control structures, and of other measures. An accelerated conservation program is essential to foster the adoption of desirable practices in critical areas of the Basin.

### Soil Conserving Crops and Crop Management

#### Seeding grasses and legumes

Grasses and legumes are recommended for approximately 20 million acres of cropland. This includes areas for permanent cover, permanent pasture, seed, hay production, and proper crop rotations. Rotation seedings are useful in building up soil fertility and soil structure and counteracting the losses from soil-depleting crops. These crops are utilized for hay, seed production, and supplemental pasture. Better balanced farming is stimulated by promoting supplemental livestock farming in connection with cash crops. The abnormal expansion of soil-depleting crops (mainly corn, wheat, and oats) during the war and post-war periods resulted in plowing up grassland, curtailing summer fallow, and disrupting crop rotations. In this connection, an adequate supply of adapted grass and legume seeds must be provided.

#### Green manure and cover crops

Adapted green manure and cover crops are recommended for the protection of approximately 13 million acres of cropland. Cover crops protect barren cropland from erosion when other crops are not growing on the land. The use of these crops as green manure adds organic matter which improves the structure of the soil, increases water-absorbing and

water-holding capacity, forms organic acids or other compounds which aid in liberating mineral plant foods, and adds to the supply of available nitrogen when nitrogen-fixing legumes are used. These crops also aid materially in reducing runoff and in guarding topsoil from either wind or water erosion.

### Crop residue management

The use of straw and stubble residues to give erosion protection to 34 million acres devoted to grain crops is recommended. Crop residue management requires tillage practices that will incorporate part of the straw and stubble into the surface soil. A large part must be left on the surface. This use of crop residues builds up organic matter and provides adequate soil cover. In arid regions of alternate crop and summer fallow, this practice offers protection from wind erosion and helps conserve badly needed moisture. The development of this practice has aided materially in discouraging the custom of destroying crop residues by fire and in other ways.

### Strip cropping

Strip cropping is recommended for approximately 20.5 million acres of relatively level cropland in the western plains. This practice, primarily a protection against wind erosion, is applied by growing alternate strips of protective and protected crops. Protective crops are close-grown grain, stubble, and strips of native sod, planted legumes, or grasses. These protect summer fallow and row crops. In light, sandy soils, strip cropping is an effective method of safeguarding summer fallow. In wind erosion areas, crop residues and cover crops, in connection with strip cropping, will permit the continued use of these lands. The protective strips help to hold snow and thereby provide moisture for subsequent crops.

### Contour Farming Practices

In many instances, crop and cropping practices must be accompanied by mechanical measures, especially on sloping and undulating cropland. They include the installation of structures and the adoption of cultivation methods that will hold surplus water or dispose of it at non-erosive velocities. Practices of this type are required if cultivated crop production is to be maintained on a large part of the undulating and sloping lands of the Basin. These practices will aid materially in reducing runoff and stabilizing the topsoil.

### Terraces

Approximately 1.9 million miles of terraces are recommended for construction on sloping and undulating cropland. Gradient terraces which



will dispose of surplus water at non-erosive speeds are needed on impervious soils and in the eastern part of the Basin. Level terraces which will hold available moisture on the land are needed on permeable soils in the western part. Terraces of proper design shorten slopes, encourage contour farming, and in general, maintain and increase crop yields. Sod waterways and protected terrace outlets must be established in all water disposal systems.

As a useful supplement to terracing systems, diversion terraces dispose of excessive runoff from drainage areas of higher elevation. In arid regions, they collect water from the steeper slopes and divert it to slopes where it can be spread for the production of crops. Diversion terraces also serve as temporary protection for drainage areas while sod waterways are being established.

#### Contour and cross-slope strip cropping

Approximately 7 million acres of sloping land, subject to wind and water erosion, should be farmed on the contour or cross-slope strip cropping systems. Alternate strip crops should be employed when contour strips will not adequately control wind erosion. Cross-slope strip cropping is useful in areas in which broken terrain makes a contour system impractical.

#### Contour and cross-slope farming

Farming on the contour is recommended for approximately 36 million acres of sloping and undulating cropland. Contour farming should be applied with terraces, on gentle slopes and in areas where contour strip cropping is not recommended. Cross-slope farming should be used when broken terrain makes contour farming impracticable.

#### Special Measures

Under specified conditions, the application of special practices is recommended. In arid regions, emergency measures are necessary when plant growth is inadequate to cover the soil during droughts.

#### Emergency wind erosion control

Emergency practices are recommended to meet the challenge of wind erosion on approximately 2.4 million acres of light, sandy soil in the arid region. These are contour listing, contour chiseling, basin listing, pit cultivation, and emergency listing at right angles to prevailing winds. These practices break the smooth surface with implements that penetrate the plow sole and bring clods to the surface to assist in preventing soil blowing.

## Land clearing

About 1.5 million acres should be cleared of trees and brush to develop and improve pasture and cropland. This land is mainly fertile areas in the river and creek bottoms. Most of it is suitable for the development of improved pastures. On small subsistence farms, where the need for cash income from all available cropland prohibits farmers from retiring land to soil-building or conserving uses, areas suitable to the continuing production of crops should be cleared. This is recommended in order to attain the most productive use. Clearing should be limited, however, to land of high quality and suitable for continuous cultivation.

### Summary of Measures for Cropland

The quantities and estimated costs of the measures recommended for cropland are brought together in table 16.

Table 16.--Measures for Cropland

Conservation Measures	Unit	Estimated Needs	Cost <sup>1/</sup>
		Thousands	Thousand dollars
A. Conserving Crops and Crop Management			
1. Seeding Grasses and Legumes	Acres	20,276	262,656
2. Green Manure and Cover Crops	Acres	13,177	103,400
3. Crop Residue Management	Acres	34,022	108,823
4. Strip Cropping	Acres	20,525	64,859
B. Contour Farming Practices			
1. Terraces	Miles	1,961	996,949
2. Contour and Cross-Slope Strip Cropping	Acres	7,090	73,780
3. Contour and Cross-Slope Farming	Acres	35,982	203,758
C. Special Measures			
1. Emergency Wind Control	Acres	2,484	11,317
2. Land Clearing	Acres	1,496	76,960
Total			1,902,502

<sup>1/</sup> Estimated total cost of installation or application.

## MEASURES APPLICABLE TO BOTH CROPLAND AND GRASSLAND

### Land Improvement Measures

The application of lime and fertilizer and the control of perennial noxious weeds are practices which are needed on both cropland and grassland. These practices require public assistance in gaining their acceptance and use. With other practices and measures, they aid in obtaining proper land use and the successful application of soil conservation measures.

#### Lime

Lime is recommended for application on approximately 20 million acres of farm land deficient in calcium and magnesium. This land lies in the high rainfall area of the eastern part of the Basin, and, in some cases, in irrigated areas, in most of the high rainfall area, lime is essential to grow legumes. Experiments indicate that legumes supply less nitrogen where lime is deficient. Lime is a first requisite to a sound crop rotation and conservation program on much of the land in the high rainfall area.

#### Fertilizers

Fertilizer applications are recommended on approximately 19.7 million acres of grasses and legumes, green manure and cover crops, and sod waterways. This acreage consists of 9 million acres of pasture land and 10.7 million acres of grasses and legumes on cropland. Recommended fertilizers include super-phosphate, potash, sulphur, gypsum, and boron. Super-phosphate is the principal fertilizer recommended in the establishment and production of soil-conserving crops. Sulphur and gypsum are used mainly in the irrigated sections to improve the soil structure and counteract alkali. Light applications of boron are needed on some of the alfalfa grown in the Upper Watershed. Public assistance is recommended only for the establishment of soil-conserving crops, legumes, and grasses.

#### Weed control

Public assistance is recommended for the eradication of perennial noxious weeds from approximately 10.6 million acres of infested farm land. In the Basin, the most common noxious weeds are bindweed (wild morning glory), Russian knapweed, hoary cress (white top and perennial pepper grass), leafy spurge, Canadian and perennial sow thistle, and quackgrass. These are a constant menace to the agricultural economy, particularly in irrigated sections where seeds are spread with irrigation water. Work should begin at the source of infestation. Proposed methods are clean cultivation and the use of chemicals.



## Minor Structures and Other Installations Associated with Land Treatment

To supplement and support the land treatment measures recommended for installation on croplands and grasslands, certain minor structures and mechanical measures must be installed. For example, when land is terraced, outlet channels must be provided. Again, minor erosion control structures must be installed in some fields to support vegetative treatments.

The kinds and quantities of measures of this type recommended for installation are described in the following. There are not included here works that are justified principally by the reduction of off-site flood and sediment benefits. These will be found in the "Program of Stabilizing Measures for Small Watercourses."

### Outlets and waterways

Approximately 431,000 miles of grassed waterways are needed to check active erosion in drainage areas on farm land and to provide for the disposition of surplus water at non-erosive velocities. Natural waterways will be reshaped, gullies will be filled, and mixtures of sod-forming grasses and desirable legumes will be established. Where fields are terraced, protected outlet channels will be constructed. Where necessary, checks, drops, diversions and other measures will be used in connection with grassed waterways when water must be conveyed over steep slopes or lowered rapidly. During installation, diversion terraces will generally be used to protect the waterway until the vegetative growth is adequate. Waterways must be maintained and protected. Heavy growth may need to be removed to permit the free flow of water and prevent smothering the sod crops. Lime and fertilizer should be used when needed to keep the vegetal growth thrifty.

### Erosion control structures

Approximately 785,200 minor erosion control structures are needed to check active erosion on fields. The structures to be built will include concrete, rubble masonry, rock, rock and brush or earth dams and concrete, rubble masonry or lumber, box drains, flumes, chutes or outlets.

### Roadside and streambank erosion control

Approximately 18,990 miles of eroded streambank and roadsides should be treated on farms and ranches by the operators. The measures to be used will include the construction of rock, concrete, wire meshing or timber riprap and the establishment of permanent vegetal cover by seeding adapted varieties of grass or planting shrubs. This practice is effective in checking erosion of streambanks and gullies, preventing erosion in irrigated or drained areas and stabilizing open cuts or fills along roadsides.

# Summary of Measures Applicable to Both Cropland and Grassland

The quantities and kinds of measures applicable to both cropland and grassland are summarized in table 17.

Table 17.--Measures Applicable to Both Cropland and Grassland

Conservation Measures	Unit	Estimated Needs	Cost <sup>1/</sup>
		Thousands	Thousand Dollars
Land Improvement Measures			
Lime	Ac.	20,340	279,487
Fertilizer	Ac.	19,724	239,715
Weed Control	Ac.	10,624	184,408
Erosion Control Measures			
Outlets and Waterways	Mi.	430,804	403,444
Erosion Control Structures	No.	785,200	376,937
Roadside & Streambank Erosion Control	Mi.	18,990	89,288
Total			1,573,279

<sup>1/</sup> Estimated total cost of installation or application.

## SUMMARY OF COSTS OF CONSERVATION AND IMPROVEMENT MEASURES FOR CROPLAND AND GRASSLAND

The estimates of the kinds and quantities of land conservation and improvement measures needed in the Missouri Basin are the product of joint consideration by all interested agencies, State and federal. They are based upon all available information and upon the knowledge, experience and judgments of technicians and farmers.

The estimated costs are sufficient to cover only the initial installation of all the measures recommended. It is assumed that the cost of maintaining the measures will be borne by the farmers and ranchers. However, it is to be understood that they will receive such encouragement and assistance in this as may be available from year to year under nation-wide agricultural programs and activities not included in the program recommended in this report.

The federal contributions listed in the tables under "Administration and Technical Assistance" and under "Direct Aids" are those considered necessary, on the basis of experience, to get the measures installed. In estimating the amounts of direct aid needed, the farmers' "out-of-pocket" expenses were taken into consideration.

The costs to be borne by farmers, as set out in the tables, include their "out-of-pocket" expenses plus the estimated value of the farmers' labor, costs of operating machinery, including depreciation, and other expenses including temporary loss of income in putting new measures into effect.

The costs of all measures recommended for croplands and grasslands are summarized in table 18.

Table 18.--Summary of Costs of Conservation Practices and Measures on Privately Owned & Operated Croplands and Grasslands

Item	Federal Costs		Private	Installation Cost <sup>1/</sup>
	Administrative & Technical	Direct Aids		
	<u>Thousand Dollars</u>	<u>Thousand Dollars</u>	<u>Thousand Dollars</u>	<u>Thousand Dollars</u>
Measures on Grassland	71,438	214,430	885,596	1,171,464
Measures on Cropland	125,017	370,858	1,531,644	2,027,519
Measures on Both	101,205	306,682	1,266,597	1,674,484
Total	297,660	891,970	3,683,837	4,873,467

<sup>1/</sup> Estimated total cost of installation or application.



## A PROGRAM FOR FOREST AND FOREST RANGE LANDS

The U. S. Department of Agriculture forestry program essential to the full development, utilization, and conservation of the forest resources of the Missouri Basin is shown for lands in four major types of ownership. These are: (1) National forests, including lands recommended for acquisition within existing boundaries; (2) lands now in State, county, and municipal ownership; (3) lands outside the national forest boundaries recommended for public ownership, whether federal, State, or local; and (4) lands to remain in private ownership. These distinctions are necessary because public responsibilities and, in some cases, the recommended improvements vary with class of ownership.

On federal lands, the program proposes to raise the intensity of management so as to attain the maximum public benefits from integrated development and use of forest lands. Similar management standards are assumed for non-federal public lands, although, of course, in State and local plans, State and local needs would be given more emphasis. The program on private lands is intended to increase their productiveness through better protection and good forest and range management practices, with due regard to the public interest.

The forestry measures have been divided into three main groups: resource capital improvements, other capital investments, and recurrent annual costs.

### RESOURCE CAPITAL IMPROVEMENTS

#### Timber Resource

##### Forest planting (excluding shelterbelts and windbreaks).

Forest planting is needed on more than 2.8 million acres of cut-over, burned-over, or otherwise denuded forest lands. Some of this is in the non-commercial zone at high altitudes where a forest cover is essential to soil stability, increased snow storage, and retarded melting. Inter-planting is needed on an additional 2.2 million acres where the stands are poorly stocked and poor in quality. In nine Missouri Basin States 1/, successful planting to date covers less than one million acres. In 1947, about 22,000 acres were planted in these States. The rate of planting will to be increased several times to bring the land to full productivity and provide needed watershed cover in 30 years.

#### Nurseries

The supply of trees for forest and shelterbelt planting is wholly inadequate to meet the planting needs. State and federal nurseries in

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1/ Excluding Minnesota

nine Missouri Basin States <sup>1/</sup> have an annual output of about 23 million trees. Only eight nurseries, with an output of about 15 million trees, are actually within the Basin. The recommended program, including shelterbelts, windbreaks, and erosion control plantings, will require an average of a quarter of a billion trees a year. Existing nurseries should be expanded and new ones established. Private nurseries also should be encouraged to grow trees for forest and shelterbelt planting.

#### Timber stand improvement

Weeding, release cutting and plantation care, pruning and thinning young stands, and other silvicultural measures are required to improve composition of the stands, the quality of timber, and the growth per acre. Included with these practices is the salvaging from public lands of bug-killed timber which is not economically attractive to private loggers. Little attention has been given to the improvement of timber stands in the Basin, except in parts of the national forests. In the next 30 years, some 2.6 million acres of plantation will need release cutting or other care; 1 million acres of young timber should be pruned, and nearly 4 million acres will need weeding, thinning, release cutting, and other stand improvement.

#### Forest Range Resource

##### Reseeding

Approximately 400,000 acres of forest range, chiefly on national forest lands, are recommended for reseeded. This is one of the principal supplemental means by which many depleted ranges can be restored to productive condition. It can be achieved only under favorable growing conditions and with protection from grazing during the period of establishment. Within recent years, reseeded has been undertaken on an extensive scale and has proved effective.

##### Fences, corrals, and miscellaneous stock-handling facilities

The estimates provide for almost 76,000 miles of fence, chiefly for farm woodlands, and more than 600 stock-handling facilities. These improvements are necessary for the control and management of livestock. Fencing is needed to keep livestock out of farm woodlands in the eastern part of the Basin because grazing is generally harmful in these hardwood stands. In the western part, many forest ranges are not sufficiently fenced to insure adequate distribution, particularly in the case of cattle grazing. The natural tendency is for livestock to gather on well-watered areas with relatively little grazing on drier and steeper slopes.

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<sup>1/</sup> Excluding Minnesota.



### Stock-watering facilities.

The program calls for developing 5,600 springs, wells, ponds, and other water facilities. Their development will encourage better distribution of livestock on western forest ranges. The availability of water in the inaccessible areas, rougher terrain, and the drier parts of the ranges encourages the use of forage which otherwise might remain practically untouched.

### Stock driveways.

The program recommends nearly 1,300 miles of stock driveways, all on national forests or other public lands. Besides offering access to isolated forest ranges, new cattle trails will relieve the congestion created by driving livestock on public roads. The work consists primarily of clearing trees and brush, some fencing, occasional small bridges, some trail building in the rougher country, and posting.

## Fish and Wildlife Resource

### Habitat improvement

The amount of work needed to improve wildlife habitats is relatively small, but it is necessary in the production and maintenance of fish and wildlife. Forest use often disturbs or destroys their natural habitats. This is clearly illustrated in streams choked by debris, in lands flooded above dams, and in livestock competition for browse. Wildlife habitat will be improved by planting aquatic plants, trees, and shrubs to provide food and shelter, and by carefully locating clearings to encourage browse and create the environment needed by many game species.

### Stream and lake improvement.

In some places, stream improvements are recommended to encourage fish life by building small dams and deflector bars to form pools and by removing log jams and other obstructions to normal migration. Improvements also will be made in lakes by stabilizing their levels, exterminating rough fish, and providing spawning facilities.

## Recreation

### Camp and picnic developments.

An accelerated program involving detailed development plans, establishment of new camp and picnic areas, rehabilitation, and the enlargement of existing areas is recommended. At present the need for camp and picnic facilities far exceeds the capacity. A continuing increase is anticipated over the next 30 years, amounting in some localities to 500 percent more than the present use.



### Winter sports

Forty-eight new winter sports areas should be developed to cope with the increasing popular participation in this form of recreation. The recommended improvements include adequate parking areas, ski slopes and trails, posted ski trails, and shelters. The national forests now lack sufficient essential facilities for sanitation and safety to keep abreast of winter recreation needs.

### Major sanitation and water systems

The program recommends the construction of adequate sanitation and water facilities on public areas where recreational use is concentrated. On many areas, present facilities are antiquated and badly in need of replacement. On others, only temporary facilities have been installed, and many are insufficient and inadequate to accommodate present use.

#### Structures.

The recommended program includes shelters, bath houses, boat landings, docks, piers, warming huts, toboggan slides, and scenic vistas. These are essential to the full enjoyment of the recreation the public forests offer. On the national forests, publicly owned organization camps are proposed for use at a small fee by churches, civic-sponsored organizations, orphanages, and other such groups.

### Water

#### Dams, reservoirs, ponds (other than for flood control purposes)

Approximately 560 small, upstream multiple-purpose structures are recommended to collect water for use in drier seasons for fire control, wildlife, and recreational purposes. In places where the streams usually become very low, a small amount of water can save fish life as well as retain recreational attractiveness. Some of the structures also serve for stream-gaging purposes.

#### Stream pollution control.

Sixty-seven barriers and other structures are recommended to prevent pollution from entering streams. The sources are mine tailings, chemical substances, and other waste primarily from abandoned industrial plants. Sewage disposal systems and measures to control sediment from soil erosion are not included in this recommendation.

## Land Rehabilitation

### Soil improvement.

The program recommends such measures as land leveling, irrigation development, and general rebuilding of the soil on approximately 97,500 acres in the national forests. This acreage consists of tracts, suitable for specialized crops and pasture, which are leased to individuals or used by the Forest Service. The installation of these measures is a federal responsibility inasmuch as the land leased to individuals is on a year-to-year basis. Reimbursement can be expected to some extent through increased production and possible adjustments in leasing rates. Any necessary water rights will be secured as provided by State law.

## OTHER CAPITAL INVESTMENTS

### Shelterbelts, Windbreaks, and Other Protective Measures

#### Insect, disease, and poisonous plant control

The recommended program anticipates the need to treat at least 300,000 acres of shelterbelt and windbreaks for damage from insects and disease during the next 30 years. This acreage would be a small fraction of the total shelterbelt plantings.

The clearance of obnoxious and poisonous plants from 330,000 acres is recommended to increase the acreage of forest grazing and to prevent livestock losses. The Klamath weed and other noxious plants have made extensive gains in recent years, while the presence of larkspur is a constant hazard to livestock.

#### Rodent and predator control.

Treatment of 8,600,000 acres for rodent control and 950,000 acres for predator control is recommended. Plantations are frequently damaged by rodents which eat the tender bark and cripple or kill young trees. In the mountain meadows, extensive rodent burrowings may dry out the topsoil and shorten the growing season for the grass cover. Predators such as the coyote and bobcat prey on livestock and at times cause considerable losses. Rodent and predator control is primarily the responsibility of the Fish and Wildlife Service.

#### Special erosion control plantings.

In addition to plantings for timber production, the program recommends trees and shrubs to control sheet and gully erosion in and adjacent to farm woodlands and to stabilize sand dunes on some 443,000 acres. Because the sites are generally poor and growth is slow, commercial timber from such plantings may never be harvested.

## Shelterbelts and windbreaks

The program recommends 245,000 additional miles of shelterbelt which will benefit 12 million acres of agricultural lands and 750,000 additional acres in windbreaks around several hundred thousand farmsteads and intermingled rural schools and churches. These plantings will serve many purposes and their establishment is a part of the conservation program on the farm.

## Administrative, Fire Protection, and Miscellaneous Improvements

### Fire control improvements

Many fire control improvements would be developed with those for administration and management. Very little mileage in roads is needed solely for fire control. The same is true of communication systems. Housing for fire-fighting crews is often located at administrative headquarters to maintain the most effective organization. For this reason, such improvements are not separated here but are combined with the recommended administrative and other improvements under a subsequent recommendation.

### Transportation system

Forest development roads and trails.---The recommended program will provide 25,000 miles in additions to and improvements in the road systems of the national forests and 5,200 miles of similar improvements in horse and foot trails. These improvements are designed to protect, develop and assure the use of national forest resources. Roads are essential to management on a sustained-yield basis. Access to remote timbered areas is required to increase the annual cut of timber from the national forests in the Rocky Mountains. For some purposes, horse or foot trails suffice.

Landing fields.---The program proposes the construction of approximately 1,120 airplane and 265 helicopter landing fields. Airplanes and helicopters have greatly increased the mobility of fire fighting crews and administrative personnel engaged in the protection and management of forest lands. Strategic landing fields can often provide sufficient access to remote country and reduce or eliminate the need for roads.

### Communication system

The public agencies operating in the Basin need some 4,200 miles of telephone lines and more than 900 stationary and mobile radio units. These installations will assure the rapid communication essential for fire control and administrative purposes.



### Structural improvements.

Additional field offices, warehouses, lookout towers, fire crew barracks, and other structures are recommended to carry out the fire control and resource management program. Housing also must be provided for technical, administrative, and protection personnel in rural areas where suitable quarters are not available.

### Surveys, Plans, and Services

#### Land surveys and maps.

New maps based on aerial photographs are needed for nearly all of the forest and forest range lands in the Basin. Accurate base maps are essential to detailed resource management plans. In parts of the Rocky Mountains, reliable maps are needed to supplement inadequate early surveys as to topography, land drainage, and sub-division lines.

#### Resource inventories and management plans.

More than 25,000,000 acres need detailed inventories of forest resources, including rates of depletion, and periodic revisions with changing conditions. Provisions are made to establish special study plots in evaluating conditions to be found in the forest and forest range lands. Detailed management plans, developed and maintained currently for these same lands, would incorporate fire control needs, transportation requirements, and other needs which are essential to the development and use of the forest resources. Such inventories and management plans will be undertaken primarily on public lands.

#### Land purchase and exchange.

The program proposes public acquisition of about 4.7 million acres. About 45 percent is within the boundaries of national forests. Acquisitions by federal, State, or local governments will be necessary where present forest land management fails to safeguard important public values. Denuded timberland and badly over-grazed range often require expensive restoration measures which private ownership cannot afford to undertake. Often lands of particular watershed value can be given the special management they require only in public ownership.

#### Signs, tools, equipment, and facilities.

Special tools and equipment are needed in performing certain phases of the program, such as fire fighting and tree planting. The estimates include, in addition, permanent signs for fire protection and administrative purposes.

## RECURRENT ANNUAL COSTS

Installation of the forestry program will require an increase in recurrent annual costs for fire protection, maintenance of improvements, technical personnel, and other services. Benefits of the program cannot be sustained unless the responsibility for protection, operation, and maintenance implicit in it are redeemed.

The proposed forestry program will be largely a continuing process by which the improved management desired on forest lands will be brought about over a long period of years. To increase the timber production on the national forests, technically trained personnel in greater numbers is needed to select areas for timber cutting, to plan cutting methods, and to supervise cutting practices in the timber sales area. The same need for personnel is present in the steadily expanding recreational use and in attaining greater benefits from all the forest resources.

Most State and county forestry agencies are inadequately staffed to administer properly the public lands under their jurisdiction. Their ultimate needs in professional personnel would conform substantially to the manpower requirements for the national forests.

Additional fire control personnel will be required to extend fire protection to private and State lands now without organized protection, including almost 73 million acres of open range land, and to intensify protection elsewhere.

Improvements installed under the accelerated program, such as roads, trails, telephone lines, lookout towers, and campground facilities, will necessitate increased annual expenditures for maintenance. These costs will increase progressively until all the structures and improvements are completed.

## ESTIMATED COSTS

### Costs for Parts of Program to be Carried Out by the U. S. Department of Agriculture

The estimated costs of work in which the U. S. Department of Agriculture would carry the federal responsibility are summarized in table 19. These investment costs are differentiated by major types of work and land ownerships. They include expenditures for material, labor, and technical personnel that are required to undertake and complete the installation of the program. Cost estimates are based upon 1947 prices. The non-federal costs shown for private lands assume that all work would be paid for at going rates. Out-of-pocket costs would be less than those shown.

Estimates of recurrent federal expenditures are shown for specified years and different class of land ownership in table 20. The increase



Table 19.- Summary of Federal and Non-Federal Capital Investments in the Department of Agriculture's Accelerated Forestry Program for Lands in Different Classes of Ownership

Class of Work	: National : State, County, : Private Lands : : Forest : Municipal : Recommended for : : Lands : Lands : Public Ownership : Private Lands : All Ownerships									
	: Federal : Non-federal		: Federal : Non-		: Federal : Non-		: Federal : Non-		: Federal : Non-	
	: Costs	: Costs	: Costs	: Costs	: Costs	: Costs	: Costs	: Costs	: Costs	: Costs
	(Thousands of Dollars)									
I. Resource Capital Improvements										
A. Timber	54,263	2,647	6,447	6,446	27,315	191,842	88,025	200,935		
B. Forest Range	14,958	740	1,996	1,996	5,082	35,568	22,036	38,304		
C. Fish and Wildlife	4,460	138	188	189	392	392	5,040	719		
D. Recreation	18,144	375	938	938	--	206	19,082	1,519		
E. Water	3,564	2	3	2	400	400	3,967	404		
F. Land Rehabilitation	1,010	--	--	--	--	--	1,010	--		
Sub-total	96,399	3,902	9,572	9,571	33,189	228,408	139,160	241,881		
II. Other Capital Investments										
A. Shelterbelts, Windbreaks, & Other Protective Measures	9,785	202	357	358	83,389	250,167	93,531	250,727		
B. Administrative, Fire Protection & Miscellaneous Improvements	170,202	1,562	6,324	6,325	110	10,187	176,636	18,074		
C. Surveys, Plans & Services	35,909	764	18,673	18,673	539	4,994	55,121	24,431		
Sub-total	215,896	2,528	25,354	25,356	84,038	265,348	325,288	293,232		
Grand Total of All Capital Improvements	312,295	6,430	34,926	34,927	117,227	493,756	464,448	535,113		

1/ A small amount of federal contribution involved in cooperative programs has not been segregated here.



Table 20.- Projected Annual Federal Costs for Additional Protection, Operation and Maintenance Involved in Department of Agriculture's Accelerated Forestry Program for Lands in Different Classes of Ownership 1/

:	:	:	:	:			
:	National	:	Recommended	:	Private Lands	:	All
Year :	Forests	:	for Public	:	2/	:	Ownerships
:	:	:	Ownership	:	:	:	:
(Thousands of Dollars)							
1954	\$ 6,289	\$422		\$472		\$ 7,183	
1959	7,461	518		482		8,461	
1964	8,533	617		493		9,643	
1969	9,505	716		505		10,726	
1974	10,411	752		515		11,678	
1979	11,319	788		524		12,631	

- 1/ A small amount of federal contribution involved in cooperative programs on State, county, and municipal lands not shown.
- 2/ Federal costs on private lands arise from cooperation with the States in fire protection. Maintenance of improvements will be borne by the private land owners and operators.

of these annual costs is projected into the future at a rate which will keep pace with the progress of installation in the capital improvement phases of the program.

Estimates for both capital investment and recurrent annual costs are confined to work to be done over and above that now being carried out in the Basin as part of nation-wide forestry programs.

The extent of federal financial assistance will vary greatly. On the national forests and other federal lands, all capital investments and recurrent annual costs would be borne by the federal government. (The assumption is made that approximately 50 percent of the private lands outside the present national forest boundaries recommended for public ownership will be federal.) On State, county, and municipal lands, federal funds would be primarily for cooperative forestry programs under the Clarke-McNary Act. On private lands, the federal contribution would not exceed 50 percent of the installation costs (i. e., shelterbelt and windbreak plantings -- 25 percent; fire protection measures -- approximately 50 percent). No federal funds are recommended for the maintenance of improvements installed on private lands. The federal government, however, would cooperate with the States in protecting these lands from fire.

Costs for Lands Under Jurisdiction of the  
U. S. Department of the Interior

The U. S. Department of the Interior has jurisdiction over some 17-1/2 million acres of open range land and almost 5 million acres of forest and forest range land in the Missouri Basin. It is recommended that measures similar to those proposed for application to other federal lands be installed on these lands. Funds for this purpose should be made available to the agency having jurisdiction. The estimated costs of installing such measures are shown in table 21.

Table 21.-- Costs of Installing Measures on Lands Under Jurisdiction of the  
U. S. Department of the Interior 1/

	:	Cost
	:	(Thousand Dollars)
I. Resource Capital Improvements		
A. Timber Resource	\$5,410	
B. Forest and Open Range Resources	7,854	
C. Fish and Wildlife Resources	189	
D. Recreation Resource	2,778	
Total -- Resource Capital Improvements		\$16,231
II. Facilitating Capital Improvements		
A. Protective Measures	2,115	
B. Administrative and Miscellaneous Improvements	9,064	
C. Surveys, Plans and Services	1,751	
Total -- Facilitating Capital Improvements		12,930
Grand Total -- Capital Improvements		29,161

1/ Does not include work on Indian lands which are leased and included in farms. Such lands are covered by the program recommended for crop land and grass land.



## A PROGRAM OF STABILIZING MEASURES FOR SMALL WATERCOURSES

The measures recommended in this Section of the Plan were estimated primarily from a survey of the Missouri River Watershed made under the 1936 Flood Control Act for the purpose of developing a program of "runoff and waterflow retardation and soil-erosion prevention." The recommended measures consist of inter-related and inter-dependent measures which should be installed concurrently on minor watersheds in the proper combination and sequence with land use and conservation practices on crop, grass, and forest land to attain, most effectively and economically, the objective of soil and water conservation and reduction of land, flood-water, and sediment damages.

Reduction of damage to land, abatement of flood and sediment damages, and continued maintenance and improvement of the land and water resources of the Missouri River Basin depend upon the proper integration and the timeliness of installation of practices and measures recommended in this report. The recommended program as a whole will increase the intake of water into the soil, retard the movement of runoff that is not absorbed, lead the water that is neither retarded nor absorbed along its least damaging route to the major rivers, and trap by suitable mechanical means as much sediment as is practicable.

The land in a watershed should be used and treated with conservation practices, as set forth in the programs for "Grassland and Cropland" and for "Forest and Forest Range," in such a manner as to develop the most favorable condition for infiltration, water storage, and yield of agricultural products. This favorable soil condition will retard a maximum amount of the rainfall consistent with the use of land for productive purposes and will reduce the rate at which runoff will reach the waterways and tributary streams.

On the other hand, it is commonly recognized that even under the most favorable land use conditions, the intensity of numerous rains will exceed the infiltration capacities of the soils, and runoff of flood-forming proportions will occur. Also, it is well known that rains often fall and snow melts when the land is already wet or frozen. This can result in the formation of damaging runoff regardless of what the use and treatment of the land may have been. This excess runoff must be conducted to the main streams in an orderly manner if damage to the land is to be reduced and downstream flood and sediment damages abated.

Stabilizing measures for small watercourses are needed, therefore, to temporarily retard the damaging runoff so that it will pass through the minor waterways and tributary channels without overflowing the bottomlands. Moreover, these waterways and channels must be protected to prevent destruction of adjacent land by erosion of unstable channel banks and beds. In many areas, gully systems on watershed lands have been caused by unstable channels which must be protected and stabilized. Failure to control excess runoff and stabilize waterways leads directly to watershed deterioration which will eventually destroy a portion of the base upon which the maintenance of good land use and conservation practices depends.



Furthermore, the stabilizing measures recommended in this Section are essential to the protection of the reservoirs authorized or proposed under the Pick-Sloan Plan. Many of these reservoirs are subject to seriously high rates of silting. Many of them are located in sub-humid and semi-arid areas of the Basin. In these areas land use and conservation practices alone will not provide a satisfactory degree of sediment control. They should be supported by stabilizing measures of the kind recommended in this program.

The broad variation in the economic development of the Missouri River Basin accounts for great differences in land, floodwater, and sediment damages from one part of the Basin to another. The diversified land, floodwater, and sediment problems and consequent damages in the Basin are also related to the wide variations in physical factors over the Basin.

## FACTORS INFLUENCING FLOOD DAMAGES

### Ozark Highlands

The Ozark Highlands are drained by the Gasconade River, the Osage River, and a number of smaller streams entering the Missouri River along the lower 125 miles of the length. These streams and their tributaries have moderate to steep stream gradients and comparatively narrow valleys.

Originally the Ozark Highlands were almost completely forested. Agricultural settlement took advantage of the most easily cleared areas, which often were not suitable for agricultural use. Damaging erosion has been the result. Unwise timber-cutting has left much poor forest cover for both timber production and watershed protection. Woodland grazing, a severely damaging practice, has been general since settlement. Fire has been, and is, used extensively to destroy underbrush and thus encourages the growth of grass in the woodlands. Misuse of forest, farm, and pasture land has accelerated erosion and increased surface runoff.

General storms, characterized by broad extent in area, long duration, and local high intensities, are comparatively frequent. Thunderstorms are common. The majority of storms producing significant runoff occur in the warm season.

Flood flows in the Ozark Highlands are, in general, flashy, and streams seldom remain above flood stage for more than 24 to 48 hours. Floods resulting from ice jams or snow-melt are practically unknown. Floods of high to medium frequency cause a major portion of the flood damage. In the Gasconade River watershed, 88 percent of the past flood damage has resulted from discharges with a calculated frequency of 10 years or less. In the Osage River watershed, tributary streams have experienced damaging floods on the average of three times a year during the last 25 years.

These small but frequent floods on tributary streams result primarily from a combination of high-intensity rainfall and fast runoff from thin soils or bedrock. They cause considerable damage on the fertile agricultural bottomlands, the best cropland in the area.

### Central Prairies

The Central Prairies are drained by the streams entering the Missouri River from the east between and including the Chariton and Little Sioux Rivers; part of the Osage River tributaries; tributaries to the Platte and Kansas Rivers in the lower 100 miles of their lengths; and by smaller streams flowing into the Missouri River from the west between the Osage and Niobrara Rivers. In general, the gradients of these streams and their tributaries are low, and the flood plains are wide and highly productive.

The rolling and hilly topography and the production of corn on the easily erodible soils have accelerated runoff and caused severe erosion in this area. Large deep gullies and serious erosion of land adjacent to tributary stream channels cause heavy loss of land. The income from continuous corn production is such that farmers are reluctant to follow recommended rotations that include pasture, hay, small grains, and legumes.

Spring and early summer rains, often of high intensity, occur when lands have the least protective cover. Rains capable of producing significant local runoff occur on an average of once to twice a year. About 54 percent of such rains occur in the summer, 24 percent in the fall, 20 percent in the spring, and 2 percent in the winter. The flows resulting from these rains, in the smaller streams, normally do not exceed flood stage for more than 12 to 36 hours but in larger drainages of 500 or more square miles, damaging stages may be sustained for 2 to 5 days. Damage from melting snow or ice jams is relatively low.

Stabilizing measures are needed to control gully development and channel erosion in the exceptionally erodible soils of this area.

### Great Plains

The southern part of the Great Plains is drained by the Platte, Smoky Hill, Solomon, Republican, and Niobrara Rivers. The northern part is drained by the north- and east-flowing tributaries of the Missouri River between Great Falls, Montana, and the Niobrara River and by all south-flowing tributaries between the headwaters and the Big Sioux River. Gradients of all streams and tributaries are low to moderate and flood plains are comparatively wide.

The Great Plains is an area of high climatic risk and includes considerable land that is marginal for crop production. The use of these lands has been influenced by rainfall and prices. A series of wet years



with favorable prices leads to the expansion of crop production, and a series of dry years with unfavorable prices causes abandonment with the land bare and vulnerable to erosion. Similarly, in favorable years, stock numbers are often built up, leading to grass and soil depletion and sacrifice sale of stock during unfavorable years. Under these circumstances, the maintenance of protective vegetation is difficult. A large part of the sediment which will seriously damage the multiple-purpose reservoirs and irrigation facilities being constructed in this part of the Basin comes from submarginal and badland areas, from gullies and erosion along small watercourses. In irrigated areas, mismanagement of water induces the problems of waterlogging, salinity, leaching, and erosion.

In the southern part of the Great Plains, rains producing local run-off occur on an average of once a year. The seasonal distribution of these rains varies from east to west with 20 to 35 percent occurring in the spring, 40 to 55 percent in the summer, 20 to 25 percent in the fall, and 1 to 3 percent in the winter. In the northern part, snow-melt is about equal in importance to rainstorms in causing floods. The snow-melt flood hazard is low in the watersheds of the Cheyenne, Bad, and White Rivers but increases to the north and west. Spring floods occur on the streams in this area almost every year. The larger streams of eastern Montana and western North Dakota are subject to ice jams.

Stabilizing measures are needed to adequately control the production and movement of sediment that will seriously damage the reservoirs and irrigation facilities being constructed in this part of the Basin.

### Rocky Mountains

The Continental Divide is the western watershed boundary from north central Colorado to northwestern Montana. The mountainous area east of the Continental Divide is drained by the headwater tributaries of the South and North Platte, Yellowstone and Missouri Rivers.

The most erodible soils and highest rainfall intensities are found at the lower elevations along the eastern slope, where Ponderosa pine, shrubs, and grasses form the natural cover. Here fire, cultivation, overgrazing by livestock and big games, logging, road building, and mining operations have caused extensive sheet and gully erosion, serious channel instability, and heavy sediment production. Erosion has not been serious at the higher, more heavily forested elevations where land use is less intensive. Local soil and channel disturbances have resulted from the above causes. The forest cover's reduced capacity to retard snow-melt, as a result of fire and heavy cutting, has been responsible for earlier and higher spring floods and heavy debris. In a number of cases this has led to channel cutting along the entire length of tributary streams. In the irrigated sections, poor water management results in increased erosion, waterlogging, loss of ditch capacity, salinity, and leaching of nutrients.



Summer and fall floods are produced by rainstorms, and spring floods by rains or snow-melt or a combination of them. General rainstorms are rare and their frequency decreases to the northward. The foothills and mountain front zone is widely known for its thunderstorms and resultant flash floods on streams with watershed areas ranging up to about 500 square miles. Thunderstorm activity decreases in the north. The U. S. Weather Bureau data reflect an average of 50 to 60 days annually of thunderstorm activity along the mountain front in Colorado and 20 to 30 days in northern Montana. Steep topography, thin soils, and intense short rains result in high peak discharges even though the total amount of water produced by the storm may be relatively small. The flash floods rise and fall rapidly and damaging stages are reached for short periods even by streams having several hundred square miles of drainage area. Occasional ice jams have so limited an effect on stream stage and damage as to make them unimportant in the flood problem.

#### DAMAGES -- KINDS AND AMOUNTS

A complex set of conditions is responsible for the wide variation in damages crops suffer from floods. These conditions, in general, fall into two major groups--namely, the characteristics of the flood and prevailing conditions on the farms.

The characteristics of the floods include such factors as depth, duration of inundation, velocity of flow, sediment and debris content, topography of flooded land, weather conditions subsequent to flood, and temperature of floodwater. Local conditions such as the direction of tillage in relation to direction of water runoff have some effect. In some cases, stored grain, haystacks, and shocks of harvested crops are damaged or destroyed. Considerable delay in spring planting is experienced in many bottomland areas every year. This is especially true in the more intensively cultivated areas. Frequently planting is delayed until normal yields can no longer be expected. Replanting is common and results in increased production costs.

Pasture damage is especially serious along larger streams where inundation may last for 48 hours or longer. Such floods deposit damaging sediment and spread noxious weeds. Damage per acre is somewhat less along small streams because of the shorter inundation, but annual damage is usually increased by high frequency.

Fence damage is widespread in the more densely settled and intensively used areas. The major part of the damage is the labor and material for repair and replacement. Other costs chargeable to fence damage include temporary loss of pasture due to broken fences, the recovery of strayed livestock, and livestock damage to crops.

Farms suffer other flood damages. Among them are losses of livestock, reduced production from livestock, and damage to farm roads, trees, farm water supplies, harvested crops, farm improvements, equipment, and machinery. However, the total is much less than the damage to growing crops.

Irrigated lands on river terraces or other areas well above the flood plains ordinarily do not suffer from the overflow. However, serious damages occur on irrigated lands as a result of floodwaters from the uplands and slopes above the supply canals. This water usually flows down gullies, gulches, small tributary streams, and other waterways from the uplands. When this water reaches the level or gently sloping irrigation units, it often floods a large area and damages irrigation facilities.

Road damage is generally greater on county and local roads than on the better designed State and federal highways. County bridges, as a rule, are not designed to withstand unusual floods, and limited funds often delay their repair. A damaged bridge is usually vulnerable to more floods. Bridge damages are unusually high in areas of active valley trenching. Here floodwaters are continually deepening and widening stream channels, undermining bridges and washing out many. Railroads feel the effect of the floods mostly in damages to bridges, culverts, and fills.

Floodwater and sediment damages to urban areas and public utilities are common in the Basin. Some of the more common are damage to water supplies, streets, business investments in buildings and inventories of goods, public utilities, and urban residences. These are much more common in the lower part of the watershed.

Streambank erosion has occurred, to some extent, in all four major physical land areas. However, the greatest amount has been suffered in the Central Prairies and Great Plains. In general, both the rate of damage and the value of the land are greatest in these areas. In addition, more intensive use of bottomlands, with the removal of stabilizing and protective trees and brush, has resulted in more severe bank erosion. As could be expected, streambank erosion is serious where valley trenching has progressed to a stable grade and channels tend to meander in stream reaches.

Land damage by scour is most severe in the eastern half of the watershed. In general, scour, caused by overbank floodwater, is prevalent where the ground lacks a permanent or perennial cover, especially in intensively cultivated bottomlands when the ground is bare. Conversely, land with a protective cover of forest, brush, pasture, and range is little affected. Light-textured soils, such as sands and sandy loams, are damaged more by scour than loams, silt loams, and clayey soils as soil particles are more easily detached by water. Scour damage is less extensive in the western half of the watershed, except in irrigated areas, because the bottomlands are used for pasture. Scour damage is greatest in the Central Prairies and along the larger streams elsewhere.



Gully erosion and valley trenching account for the greatest share of the average annual land damage. The lack of protective cover on the formerly vegetated upland areas has accelerated gully erosion. But it is ordinarily most severe in cultivated areas of rolling and rough topography. Valley trenching is the process by which the deepening and widening of channels progresses headward in established stream systems. Land damage by gully erosion and valley trenching is most serious in the Central Prairies and in the eastern parts of the Great Plains although these types of damage are found elsewhere to a lesser degree. The largest and most destructive gullies are found in the loess areas of the Central Prairies and the Great Plains where they are occasionally 80 feet deep and 200 to 300 feet wide. This type is spectacular. It often has nearly vertical sides and head and is a major source of silt. Gullies ranging from 25 to 70 feet deep occur occasionally. Those ranging in depth from 10 to 25 feet are common. Serious damage to land and irrigation works occurs in many irrigated valleys in the western parts of the Basin. Flash runoff from steep, rough, thin-soiled watersheds rushes across the irrigated valley land, cutting deep gullies and often spreading large amounts of sand and gravel over the cropland.

Infertile overwash damage depends on its depth, and the type of material. Thin layers of infertile deposits -- even at frequent intervals -- may cause only slight damage to the soil as tillage tends to mix in the deposits thoroughly. However, a thick deposit, approaching or exceeding plow depth, can cause high damages. Sandy or gravelly materials cause the greatest damage, and thick deposits of either can render the original soil unfit for cultivation. Silts and clays from less fertile upland subsoils decrease the productivity of the bottomlands by changing their structure and fertility. The highest rate of damage from infertile overwash occurs in the eastern part of the Great Plains, the western part of the Ozark Highlands, and the Central Prairies.

Swamping, the impairment of surface and internal drainage in bottomlands, is caused by sediment deposited in channels and on flood plains. Large quantities deposited in channels build up the bed and raise the water table. Sand and sandy material, deposited adjacent to the streams, form natural levees which obstruct surface drainage from lower flood-plain land. Clay and fine silt, deposited on coarser textured bottomland soils, impair internal drainage. The last two processes are the principal causes of swamping damage in the Basin. This damage was found, to an appreciable extent, only in the Central Prairies where flood-plain lands are more intensively used and, consequently, more valuable, and the rate of deposit is greater. The rate of swamping damage is not consistently high in any particular stream class.



Approximately 1,140 reservoirs in the watershed, with a capacity of 9,500,000 acre-feet of water for power, irrigation, flood control, recreation, domestic water supply, and other uses, were considered in the evaluation of sediment damage. These storage reservoirs are worth today about \$842,500,000. This value is steadily decreasing as a result of sediment which is reducing the capacity for storing water for beneficial uses. Services dependent upon stored water and vital to the economy of the watershed are being threatened. Many reservoirs, not included in those evaluated, have been greatly impaired.

The federal government and State and local authorities have authorized the construction of 119 reservoirs in the Missouri Basin with storage capacities allocated for flood control, irrigation, power, navigation, water supply, sedimentation reserve, and other allied purposes. These capacities amount to 121,580,000 acre-feet. The estimated cost of these reservoirs in terms of 1947 prices is approximately \$1,810,200,000.

The present and potential damage to existing, authorized, and partially completed reservoirs is estimated at 1947 construction costs, on equally favorable sites. This evaluation is not a true reflection of the damage to the economy of the Missouri Basin. Sites for reservoir development are irreplaceable. As reservoirs fill with sediment, replacement storage becomes increasingly more expensive. Eventually all reservoir sites will be utilized or storage capacity will have to be maintained by removing sediment at an excessive cost.

The cost of removing sediment from raw water is a significant factor in the total water treatment cost and increases with higher sediment concentration. Fifty municipalities in the watershed treat water diverted from streams. The total population served by these streams is approximately 383,000. These figures do not include municipalities diverting water from the main stem of the Missouri River below Fort Peck or below the sites of large existing or authorized reservoirs on other streams.

Sediment deposited in road and railroad ditches, culverts, and stream channels must be removed for road and railroad protection. Deposits on roads and railroads is a serious safety hazard and often obstruct traffic, and its removal is necessary for continuous and safe operation.

The damage to irrigation developments is most commonly caused by sedimentation of canals, flumes, ditches, reservoirs, and other parts of the supply and distribution systems. Water from clear mountain streams and from reservoirs with high trap efficiencies is reasonably free from sediment at most times unless it is carried into the system from the adjoining uplands. The majority of the supply systems, however,

carry heavy sediment loads from waterways draining the slopes and uplands above them. Heavy deposits in canals and ditches reduce their water-carrying capacity. A principal part of the annual maintenance charges on most supply systems is for cleaning these canals and ditches.

Practically all the sediment damage to drainage developments takes place in drainage ditches. In general, material transported from sheet erosion is the greatest source of sediment causing this damage. However, valley trenching, deep gullies, and streambank erosion contribute large quantities in the Missouri River bluff portion of the Central Prairies. In addition, many ditches are damaged by materials carried by the wind. Greatest damage is along the Missouri River flood plain. As the result of an abrupt change in stream grade, large volumes of sediment are dropped where the small tributaries cross the flood plain of the Missouri River. Damage to drainage ditches is usually considered to be the cost of removing the sediment.

In addition to the direct floodwater and sediment damage, indirect damage is important in the watershed. The more evident forms of indirect damage are interruptions in trade, transportation and manufacture, costs of flood relief, cost of policing, sanitation, and restoration of public works, and other demands on public funds and services. Less apparent, but equally important, are losses from migration, decadence, stagnation, and impoverishment in rural areas, villages, and sections of cities, disruption of schools and other public institutions, and general dislocations in social and economic relations.

Besides these direct and indirect damages, other important items of unevaluated damage must be taken into account. Some of these are loss of life, loss of irreplaceable reservoir sites, aggravated illness and epidemics, and other after-effects of flood disasters. While these unevaluated damages may not always become readily apparent, they do, however, manifest themselves in their impact upon the political, social, and economic life of the community.

#### Methods of Estimating Damages

Estimates in monetary terms were made of the average annual floodwater, sediment, and indirect damages occurring in the Missouri River Basin. These estimates are for damages that occur in sub-watersheds generally less than 3,000 square miles in area and for damages to existing and authorized reservoirs. No damage estimates are included for the parts of the Basin that are or will be protected from damage by other existing or proposed projects.

For the purpose of estimating the damages, the Basin was divided into 4 major physiographic areas and then further subdivided into 38



relatively homogeneous physical land units on the basis of similarity of soils, climate, hydrologic conditions, and other related features. Approximately 150 sample watersheds of about 5 square miles in size and 175 sample stream reaches about one-half mile in length, representing various stream-size classes up to 250 square miles in area, were selected at random and studied to determine the average annual flood-water, sediment, and indirect damages occurring within these areas. In addition, special sample studies were made to determine the average annual increased cost of water treatment due to sediment content and the average annual damages occurring to irrigation enterprises, drainage developments, and storage reservoirs. For streams draining from 250 to 3,000 square miles, annual damage figures were obtained from available data. All data obtained by these sampling procedures were expanded to physical land units. The sum of these estimates represents the total average annual damage for the Basin.

#### Estimated Damages

The estimated damages are set out in table 22.

#### RECOMMENDATIONS

The measures recommended for stabilizing small watercourses have these common characteristics:

- a. Their primary purpose is to stabilize minor waterways and tributary streams and to provide for orderly water disposal and sediment control as an essential part of a complete and integrated program of runoff and waterflow retardation and soil erosion prevention. These stabilizing measures reduce flood and sediment damages, maintain the land resources, and protect the multiple-purpose water resource developments of the Missouri River Basin against rapid impairment by sedimentation.
- b. Public benefits from flood and sediment control are dominant, although these measures also produce substantial private benefits and contribute to sound land use, and conservation practices are to be applied.
- c. They frequently involve groups of landowners and operators with common interests in protecting minor watershed units, as well as local agencies of government.
- d. They justify substantial public expenditures in technical and other assistance.



Table 22.--Estimated Average Annual Monetary Damages  
Missouri River Basin 1/

Type of Damage	:	Average Annual Damage
	:	(Thousands of Dollars)
FLOODWATER DAMAGE		
Agricultural and Non-agricultural		
Farm	56,817	
Non-farm	19,900	
Sub-total		76,717
Land		
Streambank Erosion	2,396	
Floodplain Scour	4,827	
Gully Erosion and Valley Trenching	14,039	
Sub-total		21,262
SEDIMENT DAMAGE		
Infertile Overwash	7,051	
Swamping	3,286	
Existing Reservoirs	3,159	
Authorized or Partially Completed Reservoirs	2,968	
Water Treatment	679	
Drainage	392	
Sub-total		17,535
INDIRECT DAMAGE		32,447
TOTAL AVERAGE ANNUAL DAMAGE		147,961

1/ These damages were evaluated at 1947 prices, which were current at the time of the survey. In estimating damages to land by floodwater and sediment, the present values of future income losses were capitalized at 2 percent.

### Methods of Estimating Measures Needed

The subwatershed and stream reach samples that are described under "Methods of Estimating Damages" were also used to determine the quantity and type of measures that would be required to abate the damages found. The data obtained from these samples relative to the quantity and type of measures needed were expanded to the physical land units. Thus, estimates were arrived at for the entire Basin. A range in the quantities of measures is shown since such an estimating process cannot be expected to produce exact results.

### Recommended Measures

The recommended measures for stabilizing small watercourses include establishment of:

1. Between 14,000 and 16,000 small upstream floodwater retarding structures. These measures, by providing temporary storage, will reduce flood damages caused by runoff in excess of that which can be controlled by the land use and conservation practices recommended in previous parts of this report. They will be especially effective when high intensity storms cause flash floods during times that the beneficial effects of vegetation are at a minimum. It is estimated that 4,800,000 acre-feet of storage will be provided.

Retarding measures are recommended for the protection of flood plains in many tributaries. These measures, by providing temporary storage, function to reduce peak discharges. The drainage areas above these small measures will range up to 50 square miles, and will furnish protection on the floodplains of tributaries draining up to approximately 500 square miles.

The most adaptable type of measure is a small earth-fill dam with an outlet to release water at a fixed and safe rate and a spillway adapted to site conditions. Individual reservoirs are expected to provide retarding storage ranging from 200 to 15,000 acre-feet.

2. Between 400 and 600 sediment retention structures, including desilting basins and debris basins. Desilting basins are to be developed where areas of high sediment output are a hazard to major storage projects. Debris basins are to be developed in mountain and foothill streams where the debris problem is serious.

Desilting measures, in most cases, will consist of a small earth-fill dam, a concrete outlet conduit designed to trap the desired amount of sediment, and an adequate spillway. In other cases, desilting will be accomplished by diverting

sediment-laden flows through systems of regulating dikes on gently sloping floodplain areas.

Debris basins will involve small earth and rock-fill dams, outlet conduits, and spillways adapted to local conditions.

3. Between 4,500 and 5,500 miles of minor floodways to direct damaging flows across floodplains and other flat areas where existing channel capacity is not adequate to discharge these flows.

These small floodways will consist of excavated channels and related dikes as required.

4. Between 10,000 and 12,000 miles of small stream channel improvement by stabilizing banks, removing obstructions, and installing other protective measures.

Channel improvement is required, to some degree, in practically all parts of the watershed. Continued widespread misuse of land over many years has seriously upset natural stream courses, resulting in heavy sediment, debris movements, and damage to streambanks and channels that, in many cases, cannot be rectified by land use and conservation practices. The principal objective is the stabilization of stream channels with drainage areas of 250 square miles or less. These measures include vegetation and small structures adaptable to the conditions encountered.

5. Between 750,000 and 850,000 stabilizing and sediment control measures for the control of headcutting gullies and the stabilization of gradients in upstream channels.

Measures for the control of overfalls, headcutting gullies, and gradients in upstream channels are required in varying degrees in all parts of the Basin. The objective is the stabilization of subwatershed drainageways, including road ditches and other artificial channels. These measures are drop inlets, chutes, culverts, and weir drops. Temporary construction will be used where vegetation, when fully established, is capable of maintaining control.

6. Between 180,000 and 200,000 miles of subwatershed waterway improvement to stabilize and protect natural and artificial channels.

These measures include the establishment and maintenance of grasses in the upland drainageways and artificial channels.



The waterways to be improved are those required to dispose of runoff in an orderly manner from small groups of farms.

The work consists of excavating, shaping, preparing, and seeding the waterways. Structures, needed in conjunction with the vegetative control, are included with stabilizing and sediment-control structures.

7. Between 60,000 and 70,000 miles of small diversion ditches and dikes to divert and retard runoff water in order to protect floodplain developments, eroded areas, and terraced lands.

Diversion ditches and dikes are recommended for installation within most physical land units. These measures will be used to route runoff water to selected points, to protect severely eroded areas, and to divert or retard runoff from severely damaged areas.

#### Estimated Costs

The estimated costs of installing the recommended measures are summarized in table 23.

The estimated distribution of costs shown in table 23 is based on the federal government bearing:

1. The cost of the measures on federal land.
2. Approximately 90 percent of the total cost of upstream floodwater retarding installations, and sediment retention works on non-federal land.
3. Approximately 65 percent of the total cost of floodways on non-federal land.
4. Approximately 70 percent of the total cost of channel improvements on non-federal land.
5. Approximately 50 percent of the total cost of stabilizing and sediment control installations on non-federal land.
6. Approximately 40 percent of the total cost of subwatershed waterway improvements on non-federal land.
7. Approximately 45 percent of the total cost of diversion ditches and dikes on non-federal land.

Table 23.—Estimated Costs of Installing Measures for Stabilizing  
Small Watercourses (1947 Prices)  
Missouri River Basin

Item	Approximate Number	Federal Cost	Non-federal Cost Public <sup>1/</sup> Private	Total Cost
			(Thousands of Dollars)	
Upstream Floodwater Retarding (Number)	15,000	337,000	21,000 1,000	359,000
Sediment Retention (Number)	500	58,600	4,300 200	63,100
Floodways (Miles)	5,000	8,800	2,100 2,400	13,300
Channel Improvement (Miles)	11,000	31,600	5,600 8,400	45,600
Stabilizing and Sediment Control (Number)	750,000	499,100	278,700 190,900	968,700
Subwatershed Waterway Improvement (Miles)	190,000	53,600	31,900 43,500	129,000
Diversion Ditches and Dikes (Miles)	65,000	16,700	6,900 13,700	37,300
Total		1,005,400	350,500 260,100	1,616,000

<sup>1/</sup> State and local governments, and their departments and agencies.

<sup>2/</sup> Includes \$15,396,000 for installations on lands owned or administered by State and local governments. Since a large proportion of benefits from measures primarily for reduction of floodwater and sediment damage will accrue off-site, it is contemplated that the non-federal cost will be met by a combination of the resources available to the governments of the States, counties, and other benefited local governments, depending upon circumstances surrounding the respective measures.

The recommended measures installed on lands under the jurisdiction of the federal government are to be operated and maintained by the federal government. The recommended measures installed on lands not under the jurisdiction of the federal government are to be operated and maintained by State or local agencies under arrangements acceptable to the Secretary of Agriculture and installation in any area will not be commenced until such arrangements have been made. The boundaries of any such area shall be determined by the Secretary.



## INSTALLATION BY STAGES

The recommended program of measures for stabilizing small watercourses is needed throughout the Missouri River Basin. This program is of such magnitude that it will require about thirty years to complete. Although the recommended program of stabilizing measures is based upon a survey of the entire Basin, it is proposed that only the funds needed to carry out the initial stages of the program described in this Section be authorized for appropriation at this time. Such an authorization will permit the development of more detailed plans of work and will enable the work to proceed systematically from highly critical flood and silt source areas to less critical areas.

The first stage of the program recommended in this Section will be carried out in areas of highest priorities. These areas will in general include those where flood and associated damages are greatest and where the combination of interrelated land use and conservation practices and measures for stabilizing small watercourses will produce the greatest benefits. The determination of the critical cropland areas will be worked out, where appropriate, in cooperation with the states and local public agencies. In the forested areas, early work will be directed primarily to the national forests. These public lands in the higher parts of the Rocky Mountains at the headwaters of the Platte, Upper Missouri and Yellowstone Rivers in Colorado, Wyoming and Montana particularly, contain many critical areas needing immediate attention.

The program of stabilizing measures will be extended to other portions of the Basin from time to time, depending upon progress made in installing the program, the critical nature of the problem, and the recommendations made by the interested local people to the U. S. Department of Agriculture. It is contemplated that supplemental requests for authorization will be submitted from time to time covering successive stages of the program.

The recommended first stage of the program of measures for stabilizing small watercourses is economically sound. Among the benefits to be expected are reduction in flood and sediment damage, decreased erosion, increased ground water supplies, decreased costs of water treatment, increased land productivity, decreased swamping, and other similar benefits. When the recommended program of stabilizing measures is properly integrated with the interrelated land use and conservation practices, even greater benefits will be obtained.

It is recommended that the sum of \$100,000,000 be authorized for appropriation for carrying out the initial stage of the recommended program of measures for stabilizing small watercourses. Further information as required will be supplied at the time appropriations are requested under this authorization.



## A PROGRAM IN AID OF IRRIGATION

Irrigation is essential to the fullest use of the lands of the Missouri Basin and new irrigation must be integrated into the agricultural economy of the entire Basin. The most efficient and productive use of soil and water resources in existing irrigated areas, and the integration of future irrigation developments into the existing agricultural economy are part of the program of service and assistance recommended in this report. This program will accelerate the wise and orderly use of land resources to keep pace with the development of the water resource.

In the Basin, irrigable land in existing irrigation projects totals more than 6.5 million acres, but not more than 5 million acres are irrigated in any one year. The Pick-Sloan Plan provides for the delivery of supplemental water to a number of presently irrigated areas. This plan, with the savings that can be effected through more efficient use of the water now available, will make possible the regular irrigation of 6.5 million acres in existing projects. In addition, more than 5 million acres of new land will be irrigated from water sources to be developed under the Pick-Sloan Plan. An additional million acres will probably be irrigated through private projects from ground water sources and from surface water in small tributaries. Thus the potential areas of irrigated land in the Basin approach 12.5 million acres. Even this total acreage may eventually be increased somewhat by irrigation in the more humid areas in the Lower Basin. The accompanying map indicates the major areas currently irrigated and the new areas now proposed for irrigation by the Bureau of Reclamation (figure 21).

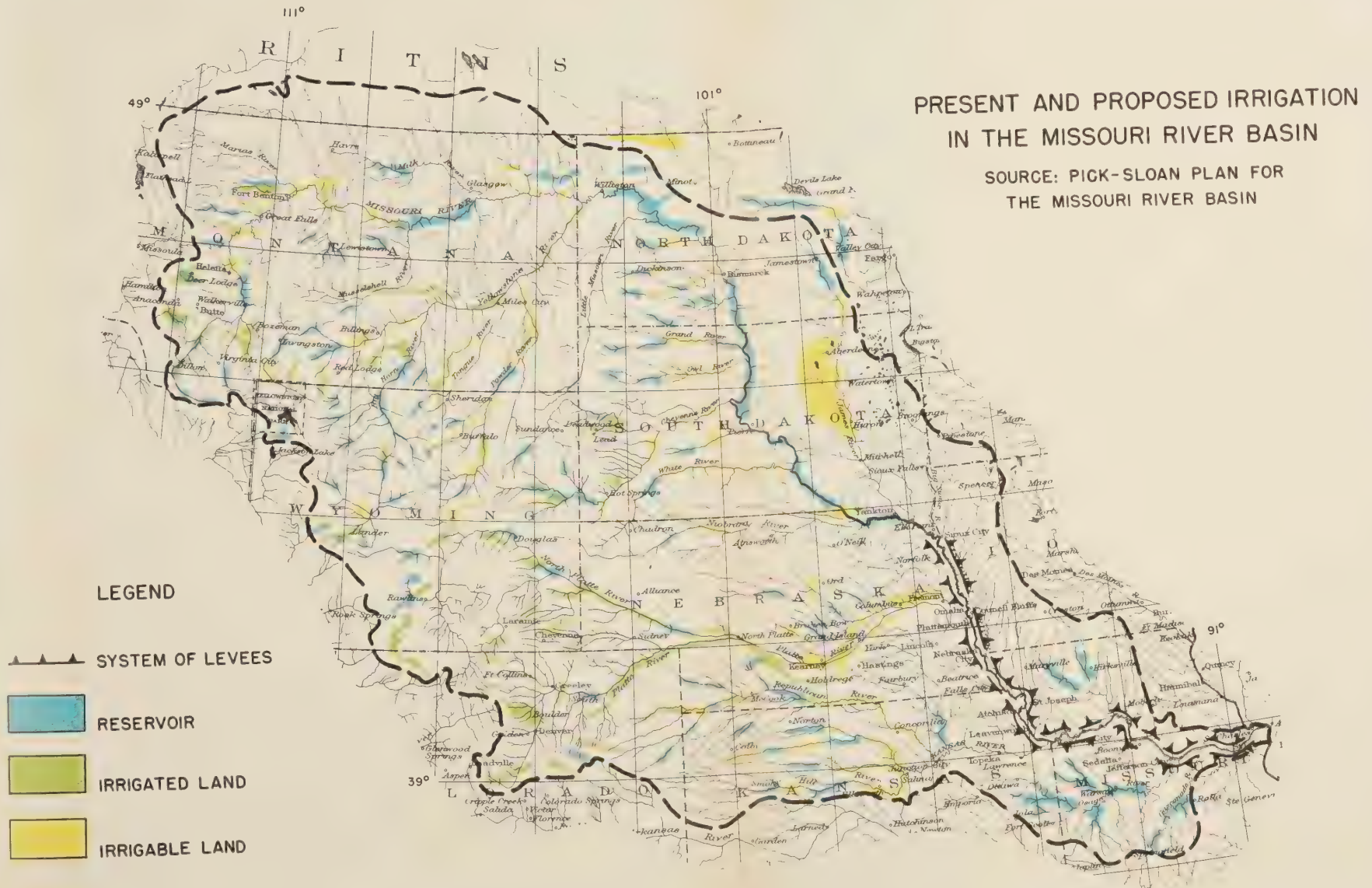
The participation of the Department of Agriculture and the Land-Grant colleges and Universities in an over-all program of irrigation in the Basin can be treated in three main categories:

1. Providing service to farmers in existing irrigated areas.
2. Furnishing factual information necessary to the planning and operating of irrigation programs and projects.
3. Providing adequate assistance and service to farmers in developing their farms for irrigation and adjusting to a new type of farming where new irrigation is established.

### ASSISTANCE TO FARMERS IN EXISTING IRRIGATED AREAS

The rehabilitation and improvement of irrigation enterprises, the improvement of individual farm irrigation systems, and the preparation of land for better use of water in existing irrigated areas offer an immediate and economical means of increasing efficiency in the use of soil and water resources. Studies of irrigation areas reveal that an increase of one-third in production can often be accomplished through the adoption of better methods.

FIGURE 21







Water for 4,450,000 acres out of approximately 5 million acres of land now irrigated in the Basin was developed through private and State initiative. The remaining 550,000 acres are supplied from projects of the Bureau of Reclamation.

Irrigation facilities serving groups of farms have been examined on a sample basis, and none has been found entirely free from problems or conditions which need to be solved or corrected.

The problems of existing irrigation systems in group enterprises, other than those constructed by the Bureau of Reclamation, embrace nearly every conceivable engineering, agronomic, financial, and management difficulty.

Those of an engineering nature range from the inadequacy of storage reservoirs, to the need for installation of measuring devices on individual farms. Between these extremes are problems relating to diversions, headgates, canal relocation, canal lining, and structures such as syphons, flumes, drops, checks, and crossings. In some instances, the consolidation of two or more separate enterprises is necessary in achieving economical use of water and land.

Drainage is one of the most serious problems induced by the application of irrigation water. Large amounts of water are lost through inadequately designed and maintained canals and ditches. Transit losses reduce the amount available at the farm and at the same time jeopardize adjacent lands by seepage. Drainage problems also result from the lack of knowledge of water requirements of crops, careless application, poorly designed farm irrigation systems, and improper land preparation. The general practice of delaying drainage construction until the need is acute has ruined some lands. A major part of the 5 million acres now being irrigated is in need of appropriate provision for removal of excess surface or sub-surface water.

The need for rehabilitating these systems is often the result of improper and inadequate maintenance. Poor maintenance is sometimes the result of lack of knowledge on the part of the operators and sometime the lack of a suitable organization. Many of the smaller organizations cannot afford the technical personnel necessary to maintain their systems. Inadequate financial arrangements often result in "patch-up" maintenance and rehabilitation.

Failure properly to maintain irrigation works has resulted in the need for major rehabilitation of a large portion of the existing irrigation enterprises in the Basin. These activities will require large investments, and satisfactory credit is often difficult to obtain for a number of causes including:

- a. The enterprise may be located in an area generally considered questionable by credit agencies.

- b. The security is not regarded as adequate by banks and credit institutions, and outstanding mortgages often limit credit advances.
- c. Limited funds prevent government credit agencies from serving all needs.
- d. The U. S. Department of Agriculture is unable, under the Water Facilities Program, to extend assistance for the rehabilitation of any one project where the cost to the federal government would exceed \$50,000. The Bureau of Reclamation generally constructs projects costing many times this amount. This leaves an in-between group of needed developments to which assistance is unavailable. An amendment to the Act of August 28, 1937, as amended, increasing to \$100,000 the expenditure limit for any one project would help to close this gap.

Although the advantages, economies, and conservation values of the proper development of land for irrigation have been repeatedly demonstrated not more than 1.2 million acres of the total irrigated acreage in the Basin are being efficiently irrigated. This is approximately 25 percent of the presently irrigated acreage. Even where lands have been properly prepared for irrigation, technical assistance in the application of water for most efficient use is needed.

The problems encountered in existing irrigated areas are so varied and extensive that they cannot be attacked in all parts of the Basin at the same time. Priorities will be established for areas to which first attention should be given. In general, the rehabilitation and improvement of existing facilities, including the reorganization and reconditioning of farm irrigation systems, will be undertaken first. This program will be expanded to all irrigated areas in the Basin as rapidly as funds and facilities will permit.

#### Summary of Proposed Program of Assistance to Farmers in Existing Irrigation Areas

##### The program of assistance to existing irrigation enterprises

Under the recommended program of aid to existing irrigation enterprises the Department will:

1. Provide assistance in planning for necessary reorganization and refinancing of existing irrigation enterprises.
2. Provide assistance to irrigation organizations in preparing plans and cost estimates for the repair and rehabilitation of existing irrigation and drainage works.



3. Provide assistance to irrigation organizations in supervising construction activities.
4. Acquire for resale land and water rights where acquisition is necessary to accomplish the efficient use of land and water resources in connection with undertakings proposed by organizations of irrigation water users. Such acquisition and resale will be undertaken only when both the organization of water users and the U. S. Department of Agriculture have exhausted all other means available to them to accomplish the desired result, and the Department will undertake such activities only upon the request of the organization of water users. All purchases and sales will be based on government appraisal and money received when such lands and rights are resold will be returned to the U. S. Treasury.
5. Provide, under the Supporting Credit Program hereinafter set out, loans for financing needed improvements.
6. Make necessary surveys and prepare, for the consideration of the Congress, reports proposing programs for the repair, rehabilitation or the extension of existing enterprises when such proposals cannot be carried out under available legislative authorities or when, for any reason, the Secretary of Agriculture considers it advisable that the Congress approve such proposals.

The program of assistance to individual farmers in existing irrigation areas

Under the recommended program the Department will:

1. Provide assistance to individuals in preparing plans and cost estimates for the repair and rehabilitation of existing farm irrigation facilities.
2. Furnish technical assistance and direct aids, such as payments, materials, equipment, and services to individual water users to further the reorganization and rehabilitation of farm irrigation and drainage systems, to aid in the preparation of land for efficient use of water, and to promote desirable land use.
3. Provide, under the Supporting Credit Program hereinafter set out, loans for financing needed improvements.



## General

For the purpose of obtaining the most efficient use of land and water in existing irrigation enterprises by the activities of both irrigation organizations and individual water users under the recommended program the Department will:

1. Promote the proper maintenance of irrigation facilities by providing technical advice and by educational methods.
2. Demonstrate to groups and to individuals more efficient methods of water application.
3. Bring to groups and individuals, through the Program of Extension Education hereinafter presented, the results of research on irrigation problems, proper land use, soil and water conservation, crop rotations, use of fertilizers, and similar subjects.

## Costs

The cost of planning and establishing the irrigation program on the 6.5 million acres of land irrigable with existing facilities is presented in table 24.

The federal costs shown are made up of the costs of technical assistance and direct aid as heretofore presented in connection with the previously described phases of the recommended over-all program. The amount of assistance required to meet local conditions and needs will vary from one enterprise to another. The cost estimates are based upon average needs.

Table 24.-Costs of Rehabilitating Existing Irrigated Areas

Item	: Acres	: <u>Federal Costs</u>	:	:	:
	:	: Technical and	: Direct	: Private	: Total
	:	: Administrative:	: Aids	: Costs	: Costs
	: <u>Thousand</u>	: Thousand	: Thousand	: Thousand	: Thousand
	:	: <u>Dollars</u>	: <u>Dollars</u>	: <u>Dollars</u>	: <u>Dollars</u>
Rehabilitation of irrigation systems	: 2,500	: 3,755	: 5,080	: 21,020	: 29,855
Land Development	: 6,500	: 28,415	: 39,680	: 163,690	: 231,785
Drainage Sub-Surface	: 925	: 3,800	: 4,645	: 19,330	: 27,775
Drainage Surface	: 1,475	: 555	: 595	: 2,510	: 3,660
Total:	:	: 36,525	: 50,000	: 206,550	: 293,075

The term "land development," as used in the cost estimates, is a general designation which includes all the various types of work needed on farm lands to secure maximum efficiency in the use of soil and water. Some of the acreage in existing irrigation enterprises requires a minimum amount of work, while other lands need complete treatment. The estimated total costs are spread over the entire acreage because it is impossible to indicate the exact acreage needing each type of work. For example, an estimated 45 percent of irrigated acreage needs some land leveling. Other percentages need surface or subsurface drainage. Still other acreages need establishment of specific water distribution devices such as border diking. Most of the total acreage, including areas where much of the physical land treatment has been done, needs continuing technical advice on rotations, irrigation methods, fertilizers and cropping practices.

For these reasons the land development program is shown for the total acreage.

#### INVESTIGATION AND PLANNING FOR NEW IRRIGATION

In view of the possibilities for greatly increasing the Basin's irrigated acreage by constructing additional irrigation works, it is proposed that the U. S. Department of Agriculture intensify and expand its program of investigation and planning for new irrigation. This is necessary to find the lands most suitable for irrigation and to determine the probable production from irrigation farming. This information is needed in evaluating the feasibility and timing of proposed new developments and in predicting their probable effects on the existing economy.

Bringing new areas under irrigation involves a heavy responsibility for adequate investigations and planning prior to making public and private investments. Incomplete investigations and inadequate planning can result in waste of investments, resources, and human effort. Many complex and interrelated physical and economic factors must be properly evaluated in making decisions of project feasibility. The skills, knowledge, and experiences of agricultural agencies is required to provide the necessary facts on which the determination of agricultural feasibility of new projects can be made and to provide a guide for planning and developing feasible projects.

It is proposed that the U. S. Department of Agriculture, in cooperation with the Land-Grant colleges and Universities, make investigations and studies of the agricultural aspects of contemplated or proposed irrigation programs or projects and prepare reports on the agricultural feasibility of such programs or projects. These investigations will involve:

1. Making necessary soil surveys and land classifications to determine location and extent of irrigable lands.



2. Determinations of the value of water to prospective water users and of their ability to repay construction, development, operation, and maintenance costs.
3. Studies of how irrigation can most efficiently fit into existing agriculture.
4. Estimates of needs and costs in preparing land for irrigation. This also will involve recommendations on the distribution of cost between private and public interests.
5. Estimates of needs for new market facilities and new market outlets.
6. Local application of research information and experience on adaptability of crops, fertility requirements, and the like.
7. Recommendations for control, distribution, and application of irrigation water.
8. Recommendations for salinity control and effective surface and sub-surface drainage based on research and field experience.
9. Cooperation with other agencies in the interpretation of underground water information supplied by geological and water supply investigations.
10. Cooperation with other agencies in securing topographic survey data in areas authorized for irrigation so that the data will be obtained in sufficient detail for use in planning land development operations for individual farms.

Areas in which the development of irrigation is underway will receive first consideration. Close cooperation with all the federal and State agencies will be maintained so that essential information is available when it is required by individuals and agencies concerned with operations programs. In areas where projects are contemplated or proposed by the Department of the Interior all investigations will be coordinated with the investigations of that agency.

Reports on agricultural feasibility prepared by the U. S. Department of Agriculture on irrigation projects contemplated or proposed by the Department of the Interior will be transmitted to the Secretary of the Interior for use in conjunction with engineering studies in determining the feasibility of such projects. Information useful to farmers and local groups concerned with new irrigation possibilities will be made available to them.



This program of investigations and planning for new irrigation will cost \$5,000,000. This is exclusive of the cost of the soil surveys and research provided for subsequently.

#### ASSISTANCE TO FARMERS IN DEVELOPING NEW IRRIGATION

Under the recommended program assistance will be made available to farmers in delineating irrigable lands and in sub-dividing large holdings into farms of suitable size. Provision will be made in a limited number of cases for the acquisition, development, and resale of excess holdings. Provision also will be made to assist individual land owners in preparing lands for efficient use of water. In some situations, the assistance provided by this program will include technical guidance in planning and establishing group facilities and developing individual water supplies. Such facilities may include pumps where ground water is available at elevations which permit economic use and where streams offer opportunities for supplemental irrigation in the less arid regions. On lands brought under irrigation for the first time, technical assistance will be provided farm operators in establishing practical and efficient farm distribution systems and in establishing good irrigation practices. Such a program will speed the transition from dryland to irrigation farming and tend to prevent the adoption of wasteful soil and water management practices which have become commonplace in many irrigated areas.

Bringing 6 million acres of new land under irrigation in the Missouri Basin will require conversion in land use from dryland to irrigation farming; technical assistance is essential in planning for such change in operations. Approximately 5 million acres will be included in the projects of the Bureau of Reclamation and an additional million acres will be irrigated in small units from water supplied by pumping from underground or surface sources and from small diversions and storage. It is proposed to make available to farm operators assistance in planning complete farm irrigation systems, land leveling, farm supply laterals, drops, checks, turnouts, crossing structures, annual ditches, and surface and sub-surface drains. It is also proposed to assist farmers in determining the areas suited to irrigation and provide them with information on soils and land capability.

#### Proposed Program of Work on Federal Reclamation Projects

The agricultural program recommended for areas to be irrigated through facilities proposed for construction under the Pick-Sloan Plan will provide:

1. Soil surveys in enough detail to furnish the information necessary for the classification of land for irrigation or other uses. (These to be provided under the Program of Soil Surveys and Land Classification hereinafter described).

2. Assistance in subdividing large areas into farms of suitable size and in integrating the use of irrigable and interspersed non-irrigable acreages.
3. Acquisition of excess land holdings where necessary to accomplish a practical subdivision and efficient use of land and water under limited conditions hereinafter described.
4. Development, settlement, and sale of acquired lands.
5. Technical assistance and direct aids including payments, material, equipment, and services to help farmers prepare land for irrigation and to establish efficient farming and conservation practices.
6. Credit for the purchase, improvement, and annual operations of farms. (Provided under the Supporting Credit Program hereinafter set out.)
7. Advice and assistance in planning necessary community facilities such as roads, market outlets, and electrification.
8. Through the Program of Extension Education hereinafter set out, information on technological improvements and demonstrations, tours, and other means of bringing results of research and experience to farmers.

The first step in the development of a new irrigation project where farmers already are on the land is an intensive educational program to enable them to make necessary changes from dryland operation to irrigation agriculture as economically and effectively as possible. This program should begin sufficiently ahead of the actual construction to assure necessary conversions as soon as possible after water is available.

Technical assistance in irrigation planning will be provided while construction is underway so that the work load will not develop suddenly upon the first delivery of water. This assistance will be on an individual farm basis and in sufficient detail to enable farmers to irrigate successfully the first season that irrigation water is delivered to the land. Insofar as possible, land leveling, installation of control structures, construction of farm supply laterals, and drainage should be completed during the pre-delivery period, and sufficient technical and financial assistance should be provided to assure their accomplishment. Complete conversion should be attained as rapidly as possible to enable farmers to meet the costs of irrigation developments with the high crop returns from irrigation.



Information regarding crop irrigation requirements and methods of efficiently distributing water will be made available to farmers on an individual basis and continually repeated in a general educational program.

To accelerate development and to provide needed financial assistance to carry out the farm plan, direct aids for approved practices and necessary credit will be available to farmers to assist them in converting to irrigated production.

The development of new irrigated lands in projects undertaken by the Department of the Interior can, in many instances, be greatly facilitated by acquisition of excess lands and their development and resale to qualified farm families. Savings can be effected in costs of community facilities such as roads, telephone and power lines, and in farm costs for fences and canal crossings. Waste corners can often be eliminated and simpler irrigation systems designed by subdividing the land on a topographical basis. Units of adequate size and yet small enough to encourage intensive operation can be encouraged so that the entire area reaches maximum production within the shortest possible time after water is delivered. Under the recommended program, however, acquisition would be undertaken only in those situations where necessary adjustments in operating units could not be readily or feasibly accomplished by private initiative and resources, and where desired economies in construction of irrigation distribution systems, preparation of land for irrigation and efficient land use could be effected in no other way. The extent of government acquisition will vary greatly in different parts of the Basin, and all purchases and resales will be based on government appraisal. The sale price of farms developed from lands purchased by the government will be in keeping with their earning capacity and money received will be returned to the U. S. Treasury. Plans for any such acquisition will be prepared after consultation with the Department of the Interior.

### Costs

Estimates of costs of preparing land for irrigation and providing the assistance described above on the 5 million acres of irrigable land in authorized and proposed federal projects are included in table 25. These estimates do not include the costs of the irrigation systems to be constructed by the Bureau of Reclamation.



Proposed Program of Work in Connection with Development  
of New Irrigation by Private Enterprises

The Department of Agriculture has a broader responsibility in the development of irrigation on the estimated million acres to be irrigated by private enterprise than on lands to be irrigated by projects constructed by the Bureau of Reclamation.

The individuals and groups of water users proposing to construct private irrigation works will need specialized help in planning and construction in addition to the on-farm assistance in preparing land for the most efficient use of irrigation water. Planning will require competent advice and assistance in respect to the availability and dependability of water supplies, the capability of the land to respond satisfactorily under irrigation, and the estimated cost of installation and maintenance of proposed irrigation facilities. These installations will require supervisory technical assistance and, in many instances, credit from public sources. Involved in bringing such land under irrigation will be the accompanying problems of land development, desirable methods of water application, farm organization or reorganization, and marketing needs, all of which will require advice and assistance to achieve desired results with the least loss in time and income.

Table 25.--Costs of Agricultural Phases of New Irrigation Development

Item	:	:	Federal Cost		:	:
	:	Acres	Technical	Direct	Private	Total
	:	:	and Admin.	Aids	Costs	Costs
	:	Thousand	Thou. Dol.	Thou. Dol.	Thou. Dol.	Thou. Dol.
Irrigation Development	:	:	:	:	:	:
private projects	:	1,000	435	6,510	23,575	30,520
Land Development	:	6,000	31,410	65,125	243,255	339,790
Drainage - Sub-surface	:	550	2,000	2,280	8,765	13,045
Drainage - Surface	:	2,500	940	1,085	4,170	6,195
TOTAL	:	:	:	:	:	:
	:		34,785	75,000	279,765	389,550

The estimated construction costs and recommended public participation with water users on the million acres to be served by private irrigation enterprises is itemized separately in table 25. On-farm land development needs are the same whether the land is to be irrigated by private enterprise or by projects constructed by the federal government and therefore no separation is made in the estimate for land development on the 6 million acres in the Basin.

# SUMMARY OF COSTS OF THE PROGRAM IN AID OF IRRIGATION

Table 26 shows a summary of costs of this proposed program of assistance and service to farmers in existing irrigated areas; investigations and planning for new irrigation; and assistance and service to farmers in developing new irrigation in the Missouri Basin.

Table 26.—Summary of Costs of the Program in Aid of Irrigation

Item	Federal Cost	Private Cost <sup>1/</sup>	Total <sup>1/</sup>
	Thou. Dol.	Thou. Dol.	Thou. Dol.
Existing irrigated areas	86,525	206,550	293,075
New Irrigation	109,785	279,765	389,550
Preliminary Investigation & Planning	5,000		5,000
Land Acquisition and Resale	(16,000) <sup>2/</sup>		(16,000) <sup>2/</sup>
TOTAL	201,310	486,315	687,625

<sup>1/</sup> Estimates of private and total cost do not include the farmers' cost for farm buildings, fences, domestic water, and running expenses essential to operating a farm business.

<sup>2/</sup> The cost of land acquisition and resale is not strictly a cost item, as all proceeds from the sale of developed farms will be returned to the Treasury. It has not been included in the totals.

A PROGRAM TO IMPROVE DRAINAGE  
ON AGRICULTURAL LANDS

The drainage of agricultural lands is an integral part of a program for the full and efficient development, utilization, and conservation of the lands of the Missouri River Basin. Drainage promotes more efficient use of available land resources and permits a shift of crop production from highly erodible and less productive lands to those better adapted to continued intensive use.

Exclusive of irrigated land requiring drainage, there are approximately 5,834,000 acres of land in the Missouri Basin that require some degree of drainage to insure full and efficient production (table 27). Approximately 1,448,000 acres of this land lies behind the levee system being constructed by the Corps of Engineers along the main stem of the river between Sioux City, Iowa, and its mouth. Approximately one-half of the drainage systems now installed to serve the wet lands of the Basin are not entirely satisfactory and require some degree of rehabilitation. In addition new drainage systems are required on some lands. These are, for the most part, located adjacent to the main stream channels traversing the eastern part of South Dakota, Nebraska, and Kansas, and the western portions of Minnesota, Iowa, and Missouri. They include poorly drained farm lands which are currently in cultivation or have been cultivated at one time or another, and some wet land that has never been put to any intensive use.

In connection with proposed levees to be installed by the Corps of Engineers there is need for the coordination of agricultural drainage with the levee system. It is essential that plans for agricultural drainage be made before levee systems are constructed to insure that the lands behind the levees will be adequately drained.

The most beneficial use of certain areas of wet land is for the preservation and enhancement of the wildlife resource and for recreation. It is not intended to drain such areas under the recommended program. It is proposed to delineate these areas during the early stages of the program in cooperation with the Fish and Wildlife Service and the State agencies concerned. Under the recommended program it is proposed to:

1. Provide assistance to drainage districts, soil conservation districts or other organized groups in planning for necessary reorganization and refinancing of existing drainage enterprises.
2. Provide assistance to drainage districts, soil conservation districts or other organized groups in preparing plans and cost estimates for the repair or rehabilitation of existing drainage systems.
3. Provide assistance to drainage districts, soil conservation districts or other organized groups in supervising construction activities.



4. Provide technical and educational assistance to individual farmers to aid them in the solution of their drainage problems.
5. Furnish direct aids such as payments, materials and services to drainage districts, soil conservation districts or other organized drainage groups and to individual farmers to further the reorganization, rehabilitation or development of drainage works and the improvement of lands for agricultural use by drainage.
6. Make investigations and prepare for the consideration of the Congress, reports containing proposed programs for repair, rehabilitation or development of drainage works when, in the judgment of the Secretary, the participation of the federal government in such proposed programs should have specific Congressional approval.

The estimated total acreage of wet land in the Basin is shown in table 27. This estimate includes lands with efficient drainage systems now in operation, lands which require improvement of systems, and lands which require the installation of drainage systems. This acreage is exclusive of irrigated lands needing drainage.

The estimated cost to the land owner of rehabilitating existing group enterprises and constructing new drainage systems to insure that all of the drained lands are placed in a high state of productivity are shown in table 28. This table also shows the estimated cost to the federal government of providing the necessary technical services to insure that the recommended improvements and new construction are properly planned, designed and constructed.

Direct aids necessary to expedite the application of the program by sharing the costs of installation on the land are estimated in table 28.

Assistance to drainage enterprises and individuals will be conditioned on adoption of satisfactory plans for adequate maintenance of the drainage improvements.

Table 27.- Estimated Acreage of Lands that Require Some Degree of Drainage 1/

State	: Land Drained or : : Suitable for Drain- : age Back of the : Proposed Levee : System	: Land Drained or : : Suitable for Drain- : age Lying Above : the Missouri River: : Levee System	: : Total Land Drained : or Suitable for : Drainage
	<u>Acres</u>	<u>Acres</u>	<u>Acres</u>
Missouri	613,000	948,000	1,561,000
Iowa	620,000	1,520,000	2,140,000
South Dakota	-	796,000	796,000
Nebraska	190,000	759,000	949,000
Kansas	25,000	327,000	352,000
Minnesota	-	36,000	36,000
TOTAL	1,448,000	4,386,000	5,834,000

1/ Does not include land in existing or proposed irrigation projects.

Table 28.- Estimated Cost of Rehabilitating Existing Drainage Enterprises, Constructing New Systems, and Assisting in Farm Drainage

Type of Work	: : Administrative : Technical	Federal		: : Total : Federal : Costs	: : Private : Total
	<u>Thousand Dollars</u>	<u>Thousand Dollars</u>	<u>Thousand Dollars</u>	<u>Thousand Dollars</u>	<u>Thousand Dollars</u>
<u>Drainage Enterprises</u>					
Rehabilitation and new construction	5,076	5,875	10,951	27,963	38,914
<u>Farm Drainage</u>					
Rehabilitation and new construction	4,448	16,543	20,991	43,652	64,643
TOTAL	9,524	22,418	31,942	71,615	103,557

## PROGRAM OF SOIL SURVEYS AND LAND CLASSIFICATION

Soil surveys will be made through the close cooperation of the U. S. Department of Agriculture, the Land-Grant Colleges of nine States, and the Conservation and Survey Division of the University of Nebraska. The Department and the respective State agencies will support the work with funds appropriated by federal and State governments and will jointly approve publication. The surveys will provide the soils information necessary to the classification of land, for different purposes, by agencies of the Department of the Interior, the Department of Agriculture, and the State agencies concerned, all working in cooperation.

### THE NEED FOR SOIL INFORMATION

To develop efficiently the land and water resources of the Missouri Basin requires accurate knowledge of the soils -- their characteristics, productivity, and location. Such knowledge is now woefully inadequate.

The soils of the Basin show enormous diversity. Some are highly productive, but others have such extremely unfavorable characteristics that to spend money for their intensive development would be foolhardy. Some will respond generously to irrigation, but others are so difficult to reclaim or give so little reward when irrigated that attempts to do so would be wasteful. Some require specific fertilizers for good crop growth; on others plants show no response from these nutrients. Some soils require intensive conservation practices to insure continued productivity; others need only good rotations and fertility maintenance.

A much accelerated program of soil surveys and land classification is needed to guide measures for land and water development and to avoid the waste of trial and error in applying measures to soils whose characteristics are not thoroughly understood.

### In land treatment.

The land treatment program proposed for the Basin contemplates applying a variety of production and conservation practices to farm, range, and forest lands according to their needs. The need for particular practices depends to a large measure on the soil and its characteristics, including its slope or surface relief. Practices needed on one farm, field, or forest site may be quite different from those required by another. Soil information is essential in choosing measures to apply to particular situations.



### In flood and sediment reduction.

The land treatment program, by reducing runoff, will reduce flood and sediment damage. Structures and other complementary measures designed primarily for flood and sediment reduction will be designed and located to take account of soil characteristics which influence their effectiveness. Here too soil information is needed.

### In irrigation.

Some soils in the Basin are well suited to irrigation, and some are not; hence, adequate soil information is imperative to select lands to be irrigated so that the limited water will be used to best advantage. Failure to do so may result not only in waste of public funds, but also in the waste of the lives and energies of people if they build their homes and irrigation farms on land unsuited for irrigation.

Soil information is needed not only to select land for irrigation, but also to determine the kind of crops to be grown under irrigation, the kind of tillage practices, the character of fertility measures, the need for and method of drainage, the method of salt removal, and the method of irrigation. Soil surveys will be designed to indicate the suitability of the soils for irrigation and to provide information useful to farmers in choosing crops and production practices that fit the soil once the irrigation is provided.

### In drainage.

The drainage program proposed for the Basin is designed to help provide adequate drainage of wet lands not irrigated. Not all wet land, however, can be economically drained. The feasibility of drainage is determined by the costs as well as by the increased production resulting from drainage. This depends to a large measure upon the soil. Soil considerations help determine whether or not it is wise to drain and they largely govern the type, depth, and spacing of drains to be used. In addition, soils influence the crops, cropping systems, and tillage methods to be chosen on lands that are drained. Therefore, the drainage program will require soil information for its successful accomplishment.

### In managing mountain lands.

The productivity and character of the soil greatly influence the growth of trees, shrubs, and grasses on mountain lands. These kinds of vegetation, like those of cultivated crops, are selective in their moisture and nutrient requirements.

Contrary to common belief, many mountainous areas have deep and fertile soils. There are also shallow and stony soils, and between these extremes are all gradations. Soils and related factors, such as types of slope and drainage patterns, are just as basic for good management practices on wild lands as they are for cultivated lands.

In management, a determination must be made as to what the wild lands can produce and how intensively they can be used without lowering the productive capacity. On some lands soils are sufficiently stable to be capable of producing timber for cutting, grasses and shrubs for livestock grazing, or a combination of land uses, and continue to perform their watershed functions. On other lands, where conditions may not be so favorable, the use of the timber, range, and other forest resources must be restricted to maintain the watershed values. Frequently, the delicate balance among inter-related factors is not recognized until destructive forces are in action. A comprehensive soil investigation can furnish additional basic data necessary to strengthen and improve present management practices on these wild lands for a greater contribution to the development of the Basin.

#### Additional Public Service

The usefulness of soil surveys is by no means limited to the essential service they will provide to the programs of land treatment, flood and sediment reduction, irrigation, and drainage. In the years ahead good soil surveys will help many thousands of individuals and public officials make better decisions in the solution of their problems.

#### Use in farming.

Aside from technical help from public agencies in the solution of production and conservation problems, farmers are constantly making their own individual decisions as to crops to be grown, rotations to be used, amounts and kinds of fertilizer to be applied, and tillage practices to be followed. Published soil maps showing the kinds and characteristics of soils on their farms enable farmers to use the continually increasing body of information obtained through farmer experience and through experiment on known kinds of soils -- known because their characteristics have been studied, their classification and location determined, and all permanently recorded.

#### Use in research.

Every field experiment is carried out on some definite kind of soil. Experimental results on one kind may not apply to another kind. Experiments should be located so as to represent important types and groups of soils in order to help predict where experimental results are likely to apply.

Growing interest in soils and land use has greatly increased the demand for more soil information, particularly by vocational schools and veteran trainees. Enlarged research activities also require more extensive information on the field properties of soils. The adaptation of new crops to special conditions is receiving added consideration. The expanding educational and research programs must be accompanied by enlarged activities to acquire the information.



### In building roads and airports.

Soil characteristics influence the design and location of many kinds of structures, particularly highways, earth dams, and airports. Foundation and pavement requirements depend on soil properties, most of which can be determined from soil maps when physical tests have been correlated with mapped soil types. Highway location is often adjusted on account of the effect of soil types on the cost of construction and durability of the road. Soil maps disclose sources of soil amendments and construction materials, such as limestone, sand, and gravel. They also provide valuable information for the selection of sites for new communities as farming practices become more intensive and population increases. The community site can be so planned that farm dwellings in a community can be best served by public utilities, schools, and other services, with the least development costs.

### In appraising land.

More equitable assessment of farm land is possible where good information is available on soil productivity. Assessors are increasingly using soil maps and their accompanying productivity ratings toward this end. Many appraisers use soil maps and reports in making appraisals for loans, to the benefit of both lender and borrower.

### To help farm buyers.

Prospective farm buyers are aided in choosing land to meet their needs through the use of soil maps and reports that disclose the productivity of the soil for different uses and crops.

### In public land purchase.

Land acquisition for certain non-agricultural public uses, like military establishments, reservoir sites, and recreation areas, should be directed toward areas of low potential for agriculture. Soil maps can provide most of the necessary information for this purpose.

## TYPES OF SOIL SURVEYS NEEDED

Since knowledge of soils is important in so many different activities and affects so many kinds of decisions, the soil survey program will be conducted so that the survey of any given area will serve as many different needs as possible. However, one soil survey of a given area cannot be expected to serve every conceivable need. For example, to make soil surveys in all parts of the Basin in the detail required for farmland in humid regions would be wasteful of funds. Land to be developed for irrigation will need even more detailed investigations, but land suitable only for grazing can be covered at a rapid rate by the surveyor.



The major types of soil surveys needed for different kinds of areas in the Basin are:

Type 1. For irrigated areas and for new irrigation projects.

On existing irrigated land and also on proposed new irrigation projects scheduled for early development, detailed surveys will be needed, usually on scales of 8 to 13 inches to 1 mile. Surveys on these areas will require a degree of detail sufficient for making farm plans. On new projects to be developed, the detail of soil mapping and classification will need to be adequate to provide the soils information required by all agencies working in the area. Deep borings will have to be made and logged at fairly frequent intervals to determine drainage characteristics of the soil. Laboratory analyses of soils will be needed to determine amounts and kinds of soluble salts, presence of alkali, and physical soil properties, with sufficient precision to assure effective use in planning irrigation and drainage systems and farm field layout, cropping systems, and practices. Field mapping will proceed at rates ranging from about 100 to 320 acres per man-day.

The average cost of surveys of this type will be approximately \$0.65 per acre, including publication. Approximately 12,000,000 acres will require surveys at this level of detail, at a total cost of \$7,800,000, including publication.

Type 2. For potential irrigated areas.

In appraising irrigation possibilities for potential projects, surveys are needed, usually on scales of 3 to 4 inches to 1 mile. Such surveys will provide the soil information required to determine the preliminary plan of development which in turn will delineate the areas to be covered by the more detailed surveys of Type 1. Field mapping will proceed at rates of from 600 to 4,000 acres per man-day.

The average cost of surveys in this type will be approximately \$0.06 per acre, including publication. Approximately 3,000,000 acres will require surveys at this level of detail, at a total cost of \$180,000, including publication for those areas not covered by a more detailed survey.

Type 3. Exploratory surveys.

Rapid surveys of some parts of the Basin are needed to provide general soils information to delimit areas justifying a more detailed examination as provided in Type 2 in connection with possible irrigation, or for other purposes requiring the delineation of broad soil areas, such as guiding the location of experiments, field trials, and demonstrations, so as to be sure they represent definite and important soil areas. Where the land is already covered by old soil maps this information can be obtained largely from them. New mapping will be on aerial photographs at rates ranging from approximately 6,000 to 12,000

acres per man-day. Surveys of this type will be scheduled in collaboration with all State and federal agencies immediately concerned with the problems requiring them and will take account of work done or planned by those agencies. Surveys of Types 2, 4, 5, or 6, where already available, and also many existing soil surveys of less detail than is specified for these types, will serve the objectives of this type.

The average cost of surveys of this type will be approximately \$0.01 per acre. Approximately 1,600,000 acres may require surveys at this level of detail, at a total cost of \$16,000. Publication of the maps resulting from surveys of this class is not contemplated.

Type 4. For humid and sub-humid areas generally.

In humid and sub-humid farming areas, except within irrigation projects where construction has been authorized, surveys generally will be needed on a scale usually of about 4 inches to 1 mile, in detail sufficient for land use and farm planning. The average rate of progress will be about 640 acres per man-day. Surveys of this type will suffice to meet the objectives of those of Type 3, and where surveys of Type 4 have been completed surveys of Type 3 will not be needed.

The average cost of surveys of Type 4 will be approximately \$0.16 per acre, including publication. Approximately 67,000,000 acres will require surveys in this detail, at a total cost of \$10,720,000.

Type 5. For the less humid dry-farming areas generally.

In the less humid dry-farming areas, characterized by the more extensive types of farming, surveys will be needed usually on scales of 3.17 to 4 inches to 1 mile, in sufficient detail for land use and farm planning, but at a level of detail permitting an average rate of progress of approximately 1,280 acres per man-day. Surveys of Type 5 will suffice to meet the objectives of those of Type 3, and where services of Type 5 have been completed surveys of Type 3 will not be needed.

The average cost of surveys of Type 5 will be approximately \$0.08 per acre, including publication. Approximately 55,000,000 acres will require surveys in this detail, at a total cost of \$4,400,000.

Type 6. For areas predominantly suitable for grazing.

In areas predominantly suitable for grazing, surveys will be needed that can be published usually at scales of  $\frac{1}{2}$  to 2 inches to 1 mile, in detail sufficient for land use and farm planning, but at a level of detail permitting an average rate of progress of approximately 2,560 acres per man-day. Surveys of Type 6 will suffice to meet the objectives of Type 3, and where surveys of Type 6 have been completed surveys of Type 3 will not be needed.



The average cost of surveys of Type 6 will be approximately \$0.04 per acre, including publication. Approximately 87,200,000 acres will require surveys in this detail, at a total cost of \$3,488,000.

Type 7. For forested mountainous watershed lands.

In the mountainous parts of the Basin covered predominantly by forests, a somewhat generalized and simplified survey is needed for management purposes. The intensity of the survey in many respects will be comparable to that for grazing lands (Type 6). Data will disclose soil associations and complex soil conditions, with recognition of parent material, texture, slope, erosive characteristics, and types of vegetation existing as ground cover. The publication scale of the map usually will be  $\frac{1}{2}$  to 2 inches to 1 mile, with rate of field progress estimated at 640 to 2,560 acres per man-day. As far as is practical, the surveys will be carried on concurrently with timber and forest range inventories.

The average cost of surveys of Type 7 will be approximately \$0.08 per acre, including publication. Approximately 25,200,000 acres will require surveys in this detail, at a total cost of \$2,016,000.

Coverage and Publication

The above types of surveys include both those made under an uninterrupted method of coverage, herein called "basic soil surveys," and those made of individual farms or groups of farms, herein referred to as "soil conservation surveys." Soil surveys, as the term is used here, include surveys made by either method.

Soil surveys employing an uninterrupted method of coverage and employing the basic soil classification, hereafter defined, are here termed basic soil surveys. Such surveys, conforming to the requirements of Types 1, 2, 4, 5, 6, and 7, according to the areas in which they are made, will be completed for the entire Basin not already adequately covered. Definitely bounded areas ranging in size from about 50 to several hundred square miles will be adopted as survey units. In irrigated areas, the irrigation project and, in other areas, the county will generally be the unit of survey. A single publication containing maps and reports will generally be issued to cover each survey unit. In irrigated areas, one publication may cover two or more adjoining irrigation projects, provided the timing of surveys in the two projects makes such procedure feasible. The survey unit will extend somewhat beyond the existing or proposed irrigated land to facilitate possible adjustments in the boundaries of the project or to include non-irrigated lands likely to be operated within farms also using irrigated lands.

A county containing both irrigated and non-irrigated areas may be covered with a single publication in which separate maps covering irrigated and non-irrigated portions may be included.



After a survey has been initiated in a survey unit, mapping will progress substantially with geographic continuity until the whole unit has been covered. This continuous method of coverage has been found more economical than the separate coverage of non-contiguous farms or other small tracts. Consistency in the nomenclature and classification is easier to maintain.

Field maps and other pertinent information will be reproduced for agencies having immediate use for them without waiting for publication.

Complete coverage of all lands in the Basin will not be available for a number of years due to the limited number of technically trained personnel and limitations on the speed with which new personnel can be trained. Agencies needing surveys of individual farms will make surveys of such farms or groups of farms as required to carry out their operations as provided in the following paragraphs.

In order to meet operational needs in areas where adequate basic soil surveys have not been provided, agencies requiring surveys of individual farms or groups of farms or irrigation projects will make such surveys in accordance with the principles and agreements set forth by the Joint Committee on the National Soil Survey in January 1945.

Surveys of single farms or groups of farms made to meet operational needs are here termed soil conservation surveys. Soil conservation districts now in operation are being assisted to help land owners and operators make farm and ranch conservation plans at the rate of about five million acres per year. Soil conservation surveys will be made on individual farms or groups of farms to meet this need each year. In addition, surveys will be made to obtain supplementary information on physical land conditions where needed in soil and water conservation programming or planning. Soil conservation surveys may be published where contiguous covered areas are of sufficient size for the publication to be useful to the general public.

In these surveys soil differences will be determined according to criteria established by the agency making them to meet its requirements and the soils may be named later according to the basic soil classification. The rates of coverage and the degree of detail on these surveys will be in accordance with the types listed for the different kinds of areas.

In carrying out a basic soil survey of a designated survey unit, the utmost possible use will be made of individual farm surveys already completed. The individual farm surveys can be used so as to reduce significantly the cost of the basic soil survey.

Where adequate soil surveys cannot be made available in time to meet the needs of the Bureau of Reclamation, this agency is expected to collect the necessary soils information, in cooperation with the various States, along with topographic, drainage, and other data necessary for land classification according to Bureau of Reclamation standards and specifications.

The cost of surveys of single farms or groups of farms made to meet operational needs and the cost of adopting or supplementing basic soil surveys for this purpose are included in the cost of the particular program requiring them.

### Features of the Surveys

#### Basic soil classification.

The basic soil survey will identify and classify the soils as types and phases according to the nation-wide system of soil nomenclature. This will be the basic soil classification. Units of the basic soil classification will then be grouped into various practical land classes showing, for example, productivity under irrigation.

Soil types will be subdivided into phases so as to express differences in soils, slopes, erosion conditions, and other factors as required to meet the needs previously described.

Surveys of individual farms made in advance of the basic soil survey by an agency to meet its immediate operational needs will not necessarily employ the basic soil classification, but will do so wherever the agency finds it feasible.

#### Laboratory analysis and aerial photographs.

All surveys will be supported by laboratory analyses sufficient to enable proper classification of soils for the purposes intended to be served by the survey.

Field base maps for surveys will be aerial photographs wherever practical. In some areas, topographic maps may be used.

#### Interpretation and classification.

In addition to the basic soil classification the soils information will be interpreted into various useful classifications according to the needs of operating agencies and for the information of the public. These may include:

- (a) Classification according to productivity, including predictions of expectable average yields from different soils.



- (b) Land capability classification: A classification of land according to its characteristics, including climate, that affect its usefulness, its limitations, and the hazards to which it is subject under cropping, grazing, and forestry uses.
- (c) Special classifications according to need for fertilizers, lime, salinity control, drainage, and erosion control measures as required by problems of the areas.
- (d) Ratings of soils as to permeability, infiltration capacity, moisture retentiveness, erosion hazard, and forest site quality as required by problems of the area.

#### EXISTING COVERAGE

Approximately 107,287,000 acres of the Basin have been covered with soil surveys published principally in county units (fig. 22). Not all meet the requirements of the types of survey here specified for the kind of areas which they covered. Surveys covering a total area of about 19,000,000 acres are in progress.

Approximately 31,599,000 acres have been covered with surveys adequate for farm planning. Most of this acreage is in surveys of scattered farms, but a few whole counties and other large geographic units have been covered in this degree of detail.

#### SUMMARY OF RECOMMENDED PROGRAM

The States historically bear a part of the cost of soil surveys. It is expected that they will continue to participate in this work, at a rate at least as large as in the past and probably at an accelerated rate. Due to the greatly accelerated rate of progress recommended here, however, the States are expected to be able to bear considerably less than half of the cost. Federal expenditures for this work will be made where the States also participate, but it is not possible to determine what share the States will be able to bear.



# BASIC SOIL SURVEYS COMPLETED IN THE MISSOURI RIVER BASIN

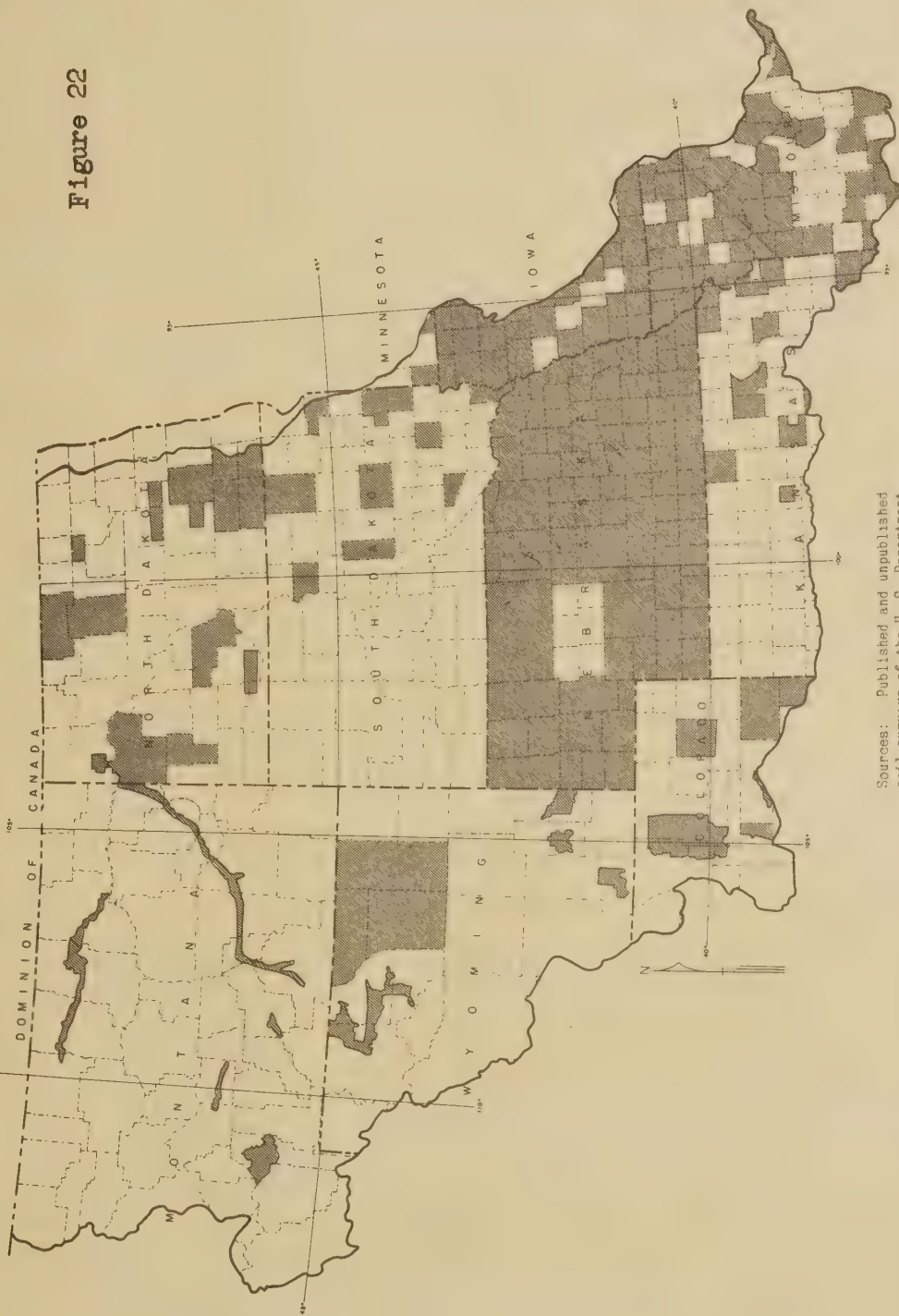


Figure 22

Sources: Published and unpublished soil surveys of the U. S. Department of Agriculture and the various states.



Table 29 - Estimated Acreage and Costs of Soil Surveys 1/

State	Acres	Cost (Federal and State)
Colorado	15,300,000	\$ 2,200,000
Iowa	9,000,000	1,580,000
Kansas	21,300,000	3,100,000
Minnesota	700,000	100,000
Missouri	9,000,000	1,400,000
Montana	75,100,000	5,800,000
Nebraska	9,600,000	2,270,000
North Dakota	36,100,000	5,470,000
South Dakota	37,500,000	4,200,000
Wyoming	35,200,000	2,500,000
Total	<u>2/</u> 248,800,000	\$28,620,000

1/ Excludes costs of surveys of individual farms or groups of farms made to meet immediate operational needs arising before coverage of whole survey areas is afforded. Costs of such surveys are borne as part of the costs of the programs requiring them. Costs estimated in these tables take account of expected use of such surveys of individual farms in preparing soil maps of whole survey areas.

2/ Net acreage, excluding areas to be covered a second time, by a more detailed type of survey.

Table 30 -Estimated Acreage and Costs of Soil Surveys by Types 1/

Type	Acres	Cost per Acre	Total Cost (Federal and State)
1	12,000,000	.65	\$ 7,800,000
2	3,000,000	.06	180,000
3	1,600,000	.01	16,000
4	67,000,000	.16	10,720,000
5	55,000,000	.08	4,400,000
6	87,200,000	.04	3,488,000
7	25,200,000	.08	2,016,000
Total	251,000,000		\$28,620,000

1/ Excludes costs of surveys of individual farms or groups of farms made to meet immediate operational needs arising before coverage of whole survey areas is afforded. Costs of such surveys are borne as part of the costs of the programs requiring them. Costs estimated in these tables take account of expected use of such surveys of individual farms in preparing soil maps of whole survey areas.



## PROGRAM OF RESEARCH AND INVESTIGATIONS

Research and investigations needed to support the recommended programs of land and water development have been designed through the combined efforts of scientists of the U. S. Department of Agriculture and the Agricultural Experiment Stations of the Land-Grant Colleges of the Missouri Basin. <sup>1/</sup> The program will be carried out largely through the close cooperation of these groups, with appropriations provided by both federal and State governments.

Agricultural research is a primary source of the present high level of production on American farms. Farming has many hazards in addition to those that beset most other businesses. Unpredictable weather, insects, and plant and animal diseases open farming to more than usual business risks. The difficulty of the thousands of individual producers acting together to adjust their production to market demand adds the risk of more severe price fluctuation than in most other enterprises. Farmers have a complex problem in the development and conservation of their land resources. A vigorous and resourceful research program in the past has given us such things as high-yielding and disease-resistant plants, effective insecticides, labor-saving machines, and market-outlook information which have greatly increased the security of farm people.

However, special research is imperative beyond that which will be afforded through the continuation of that part of the present national and State research programs within the Basin. Accelerated research is needed to precede and guide the greatly expanded programs of irrigation, drainage, land treatment, and watershed management in prospect for the Basin. Problems arising in the development and use of particular areas have not been and are not likely to be answered by investigations not specifically designed to meet them. For example, each of the large irrigation projects presents problems peculiar to itself, such as how and when to irrigate, what farm enterprises to encourage, what cropping systems to follow, what fertilizers to use, and what sizes and types of farms are suitable. These are not answered by general research on irrigation development, nor by investigations of any but the actual areas to be irrigated.

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<sup>1/</sup> This program was developed from the "Preliminary Report of Agricultural Research Projects for the Missouri Basin," by the Regional Technical Committee on Research, State Agricultural Experiment Stations, U. S. Dept. of Agriculture, and U. S. Dept. of the Interior cooperating, Lincoln, Nebr., Feb. 10, 1949.

Similarly, measures to manage and conserve watershed resources require investigations dealing with the combination of soils, topography, climate, drainage, and vegetal cover existing in specific areas. Research at the rate heretofore carried on cannot be expected to provide answers to problems peculiar to all the different, yet important, situations in the Basin.

The research recommendations herein are designed to furnish the factual basis for the accelerated program of land, forest, and water development and assure its full completion with the least use of costly trial and error.

The several classes of essential supporting research include the following: (1) Conservation and management of farm and ranch lands, (2) management of forest and range lands, (3) reduction of water runoff and sediment, (4) development of irrigation, (5) development of drainage, and (6) research on weather-tolerant plants, insect control, farm machinery, and farm engineering for efficiency in use of labor and power. Each of the first five classes is needed to support a segment of the recommended land, water, and forest development program. The sixth is of importance to all segments of that program.

But all the research requirements that may emerge during the 30 years in which this far-reaching river basin development program is in progress cannot be foreseen. Therefore, the accelerated research program will be adjusted from time to time to meet such needs. After the initial 10-year period, attention also will be given to investigations in such as family living, crop utilization, and animal production. With the completion of the development program, the research work will be adjusted to a level compatible with maintenance needs.

## CONSERVATION AND MANAGEMENT OF FARM AND RANCH LAND

### Management and Conservation of Soil and Water

Limited studies indicate that from 30 to 50 percent of the original nitrogen and organic-matter content of most soils of the Basin have been lost by decomposition and erosion. Decreased levels of nitrogen and phosphorus tend to limit crop yields in years of favorable rainfall. Infiltration of rainfall is too low, and too little moisture is stored to supply crop needs. This condition has increased the hazards of runoff and erosion on uplands with subsequent silting of reservoirs, stream beds, and fertile bottom lands. The problem involves the use of contour tillage, terracing, and other mechanical practices as well as finding methods of producing crop cover and methods of providing crop residues to reduce runoff and erosion. Experimental work in the humid region indicates that the use of lime, crop residues, fertilizers, and adapted legumes are promising techniques in making poor and eroded soils produce good crops. To what extent these and other practices are adapted to the different soil and climatic conditions of the Basin, particularly the part that receives less than 25 inches of rainfall, is unknown.



Recommended research.—The research program will be expanded to include more experimental comparisons in various cropping systems; residue management; fallow, tillage, and soil treatment procedures, depending on the agricultural potentialities of a particular area. The effects will be studied in relation to control of weed growth, water conservation and utilization, crop production and fertility maintenance, and residue control of wind and water erosion. These studies will involve comparisons of the various types of vegetal cover and soil treatments, contour furrows, terraces, and other mechanical devices in reducing erosion and runoff. Methods will be studied for improving the chemical, physical, and biological properties of the soil. Periodic determinations will measure the changes that take place in these properties. Also included will be studies of soil treatments and cultural methods with various legume and non-legume crops and ways of integrating the use of such crops into good soil-management systems. Special research will be made on methods of improving the productive capacity of badly eroded soils and of preventing further erosion of these soils.

#### Improved Legume and Grass Seed

The importance of grass and legume forage crops for soil conservation and as elements in economical farm management is being recognized in the Basin. The necessity of keeping land protected with a growing crop has become more apparent as more land has been put into cultivated crops. In order to keep the proper acreages in pasture or hay, enormous quantities of seed are necessary. The shortage of seed has limited the use of these forage crops for soil conservation. The requirements are for species and varieties best adapted for use on the different soils and under the differing climatic conditions of the Basin. Only limited quantities of seed of these most desirable kinds have been produced, and the most efficient possible methods of seed production have not been developed. Not many growers have made a specialty of growing seeds of these adapted legumes and grasses because not enough information is available on the methods and soils to use.

Recommended research.—Methods of seed production will be studied, including soils, systems of planting, and ways of harvesting and processing seed in order that it may be in most satisfactory condition for planting and for germination. Investigations will discover the effect of treatments such as irrigation, cultivation, fertilizers of different types, and place in rotation on maximum production from high quality seed.



## Grassland Management and Forage Utilization

Good grassland with vigorous, dense stands is one of the most effective of the available erosion and runoff controls. Land-use objectives call for the maintenance of the large existing acreage of grass, a shift of about 10 million acres of crop land to permanent grass cover, and a shift of a considerable additional intertilled acreage to rotations, including hay and pasture. The effectiveness of this phase depends upon what management practices are adopted. They will determine the extent to which farmers and ranchers will use grass as a major crop. Each type of grass and grass-legume mixture requires its own kind of management, fertilizer treatment, and cultural and grazing practices. These must be modified according to changes in climatic and soil factors. The acceptance of this program also will depend upon developing management systems and methods of utilizing the forage for profitable production of livestock and livestock products.

Recommended research.—The most desirable grazing and feeding practices will be ascertained for various types of pasture. New varieties of grasses and legumes as well as grass-legume mixtures will be tested for use in livestock production. The economy of using more pasture and forage in production of animals for slaughter will be studied as well as the most efficient use of these forages in dairy-herd management practices. Methods of harvesting and storing grass and legumes for use as hay and silage during between-pasture seasons will be studied.

## Economic Research

### Economic problems of conservation

The general public is interested in conservation in terms of the long-run well-being of the Nation. An individual farmer, however, often must judge proposed conservation measures by short-run costs and returns. The success of the conservation program depends upon the use of the recommended measures by thousands of land owners and farm operators and upon the type and scope of governmental participation in land conservation. Problems involved in obtaining adoption of conservation land-use practices must deal with an analysis of the cost-income balance of present systems of farming and land use in contrast to returns from recommended conservation practices, evaluation of public benefits and costs from conservation farming, study of necessary tenure arrangements, other needed institutional adjustments, and inducements and incentives that will be required if a well-balanced land conservation program is to be achieved. Such studies are necessary in order to learn to what extent land owners and operators can afford to adopt land conservation measures and the degree to which public assistance is necessary and desirable in the interest of national welfare.

Recommended research.—Research will include an analysis of probable costs and returns from various types and combinations of land-improvement and conservation measures, public interests and responsibility in conservation measures on private land, and probable obstacles to recommended land-use practices and conservation measures and how to meet them.

Problems created by flooding land in reservoir sites

When the government takes over privately owned land in order to use it for reservoir sites, some farmers have to move, land is taken out of agricultural production, and local communities and local governments are disturbed. About 2.5 million acres of land and possibly 4,000 farms are involved in the proposed reservoir sites in the Missouri Basin. In some cases, not all of the land within a reservoir area is permanently flooded; part of it may be used for agricultural purposes.

Recommended research.—These problems will be studied to determine possible opportunities for displaced farmers, how best to use land that is flooded only occasionally, and how to adjust the finances of local governments. The studies will also seek ways of reducing the local impact of adopting sites for reservoirs.

Economic arrangements to reduce instability of tenure and income

The heavy investments contemplated in the Basin are expected to improve the physical basis for better use of human as well as natural resources. However, improvements of this kind can be largely offset in the case of individuals by lack of suitable rental agreements, tax procedure, credit arrangements, crop insurance, and suitable methods of building financial reserves. This is particularly true in the Great Plains where variations in weather and prices have created great instability of tenure and income.

The experience of the Great Plains during the last two decades is proof enough that improved resource utilization calls for special arrangements to safeguard farm tenure and to stabilize income.

In the droughts and depression of the 1930's, many families lost their farms because of mortgage foreclosures and tax delinquency. During and after the recent war, the combination of favorable weather and high prices brought about a remarkable recovery. There are fewer tenants than at any time since 1910 and less mortgage indebtedness in 1947 than at any time since 1920. Whether this prosperous state of affairs continues depends first on the weather and on grain prices and second on the extent to which the farmers are protected by financial reserves, adapted mortgage credit, tax laws, and rental agreements, crop insurance and price supports, feed reserves, and good land-management practices.



Recommended research.—The experiences of the past will be studied as a basis for determining what economic and financial arrangements should be made to prevent the widespread disasters that have affected this region. Research will include ways of increasing security of tenure under variable income, methods of variable payments under credit and rental contracts, adjustments to avoid tax delinquency, modification in credit to meet varying needs for operating capital, and the extent the variations in crops and income may be reduced by building farm feed reserves and by crop insurance and grain storage programs for the area.

## FOREST AND RANGE RESEARCH

Forest and range lands are sources of, singly or in combinations, water supplies, timber for lumber and other products, forage for grazing, wild game, and recreation. In many places, poor timber-cutting practices, overgrazing, and fire have reduced the productive capacity and impaired watershed values. Expanded research is needed to strengthen the basis for more effective management of these forest and range lands.

### Watershed Management

The rate of flow, seasonal distribution, and usability of surface water for irrigation, power, and domestic uses is greatly influenced by the conditions on watershed lands. The density of forest vegetation and the presence of litter have a regulating influence on the accumulation and melting of snow, the percolation and storage of water in the soil, and the usability and yield of water from the watershed lands. In the Rocky Mountains and the Ozark Highlands, where the greatest annual precipitation occurs, healthy conditions in the forested headwater areas is essential to increase the usability of water for irrigation, power, domestic purposes, and navigation and to reduce the hazards from floods and sedimentation. In the plains areas, trees and shrubs are needed to conserve moisture, to protect lands from floods and streambanks from erosion, to shelter farmsteads and other plantings from sun and wind, and to shield roads from drifting snow.

Recommended research.—A research program will give findings on a great variety of questions. Among them are the effect of different methods and different intensities of forest and range use on the production of usable water and improved methods of cutting and utilizing timber and forage resources so as to reduce soil erosion, siltation, and flood damage as well as to obtain maximum yield of water of good quality. The conservation of snow melt and rainfall for use during critical dry periods, for protection of maximum usable water supplies, and for replenishment of ground water supplies likewise needs more investigation. Research also is needed in the most rapid and economical



means of reducing accelerated wind, sheet, gully, and streambank erosion and the best ways of obtaining maximum benefits from shelter-belts and farmstead plantings.

### Forest Management

The timber resource now supplies only 20 percent of the local needs for lumber and wood products. This is a fraction of their potential contribution on a sustained-yield basis. When large blocks of mature timber stands in the Rocky Mountains are cut, productive growing stock should be retained for reproduction. In the hardwood forests in the eastern part of the Basin, commercial cutting has taken the best with insufficient care and attention to replacement. Overcutting, overgrazing, burning, and, in some instances, unwise land clearing have greatly reduced hardwood forests and impaired their quality and productiveness.

Recommended research.—The research program of forest management will give findings on the best methods to use in converting mature and overmature forests to thrifty growing timber stands, ways and means of promptly reforesting cut-over lands, and the best practices to improve both quantity and quality of tree growth. The rehabilitation of areas depleted by fire, insects, diseases, and destructive logging will be studied. This includes the problem of producing trees for planting more economically. Harvesting methods that will not be injurious to the land and that will encourage the growth of uncut trees into valuable timber form another research problem.

### Range Management

In the Missouri Basin, a greater area is devoted to range livestock production than to any other land use. Ranges support millions of head of cattle and sheep for a part of each year. But vast areas are deteriorated, produce only a fraction of what they are capable, and permit serious accelerated soil erosion.

Recommended research.—The research program will search out the best adapted practices in range utilization so as to produce greater livestock values as well as maintain and improve the forage resources. Range reseeding problems involve research in species, mixtures, and methods. The study of economical methods of controlling brush, weeds, and other noxious plants on the ranges can prove especially valuable. Criteria for judging range conditions also need investigation.

### Fire Control

The successful management of forest and range lands cannot be attained without adequate fire protection. At present, losses from fire in many parts of the Basin exceed the standards of good land

management. Recovery from the destructive effect of fire is slow and in some cases takes decades. Repeated fires have resulted in losses of timber, ground cover, and the soil's productive capacity.

Recommended research.—The research program will be directed to finding ways of reducing losses, through the development of better principles and tactics in fire control, improvements in fire fighting equipment, and more accurate predictions of fire weather.

### Forest Products

A considerable proportion of the present timber supply is made up of species which have little demand or commercial value. Most of the remaining hardwood forests are composed of small trees of low quality. Meanwhile, some of the virgin pine and fir stands in the Rocky Mountains remain untouched because of inaccessibility. The problem of waste is present not only in logging practices, but also in the manufacture of timber and other wood products.

Recommended research.—The research program will be directed toward such solutions as the development of new and better ways of using wood, especially the less desirable species, and improved techniques in cutting timber to reduce waste.

### Forest Economics

Too little attention has been given so far to analyzing the benefits to be derived from the forest resources. Further economic data are needed in evaluating possible contributions of the recommended forestry measures to the agricultural and industrial economy of the Basin.

Recommended research.—The research program will be directed to the development of a comprehensive inventory of timber, range, and upstream water resources, to studies of use-owner-tenure relations, and to studies of markets for forest products and of marketing problems.

## REDUCTION OF WATER RUNOFF AND SEDIMENT

### Effect of Land Use and Farming Practices on Water Runoff

A great deal of information obtained from plot experiments emphasizes the seriousness of the losses of both soil and water from agricultural lands and indicates generally the effects of land use on runoff, erosion, ground water, and floods. But these small-plot experiments do not reveal the performance of natural watersheds and field areas. Research at the hydrologic experiment station at Hastings, Nebraska, provides information on watershed performance applicable to the Great Plains of south central Nebraska and north central Kansas. However, the information being obtained there will not be directly applicable to the many other conditions throughout the Basin.



Reliable information on the runoff characteristics of small agricultural watersheds in the Missouri Basin, ranging from 100 acres up to 15,000 acres, is practically non-existent. The U. S. Geological Survey has information on the amounts of runoff from large watersheds, but experience indicates that such data are not applicable to the small watersheds usually involved in a soil and water conservation program. Thus, there is need to obtain more information on the runoff characteristics of the intermediate-sized watersheds.

Recommended research.--In addition to the hydrologic experiment station, including watersheds from 3 acres to 3,500 acres, at Hastings in the Republican River watershed, three or more similar stations are proposed at other locations in the Basin. These will represent different soil, topographic, and climatic conditions. By means of water-stage recorders and rain gages, the relation between rainfall and runoff for various watershed and land-use conditions will be ascertained. Studies will be made of the gains and losses in water after it has left the field, pasture, range, and forest and entered the channel system. The amount of water absorbed or impounded on the flood plain, the amount gained from contributing groundwater, and the resulting effect on total stream flow will be determined. In addition, gaging stations on typical watersheds, ranging in size from 100 to 15,000 acres, are proposed to learn the relationships between rates and amounts of runoff and size of the watershed. Existing culverts and bridge openings will be used, where possible, to reduce the cost.

#### Control of Reservoir Silting by Watershed Treatment

Silting is one of the major problems in planning and maintaining storage reservoirs in the Missouri Basin. Data mainly from the Corps of Engineers and the Bureau of Reclamation give evidence that under existing land-use conditions the average annual loss in reservoir storage from silting exceeds 250,000 acre feet. At the present cost of reservoir storage, this represents an annual loss of about 6 million dollars. This fails to reflect the full loss as most of these reservoirs cannot be replaced. As the only available sites are called into use in many parts of the Basin, lost storage means a gradual decline in irrigation, power, and other values. More needs to be known about the erosion of different soils, its production of sediment, and its influence on useful life of reservoirs.

Recommended research.--Useful research will be directed at long-term sediment-production indexes for all important physical land units and sub-basins. Techniques and field methods for determining the sources of damaging sediment within sub-basins will be studied. The effectiveness of land uses and conservation practices on sedimentation is an essential field of investigation which involves surveys of runoff, sediment-load, small reservoirs, and stock ponds in sub-watersheds.



## Channel Stabilization and Control of Sediment Movement

A large part of present-day flood damages to farm land, roads, structures, and irrigation projects result from severe erosion of channel beds and banks in some sections and rapid silting in others.

Silting is rapidly diminishing the capacity of canals in many irrigation projects and exhausting reservoir storage. Stream channels and natural waterways cannot quickly revert to their original condition even under a program of good land use. They must, in some instances, receive specific protection and stabilization to reduce the excessive damages they now suffer. The need for protection is not confined to main streams but extends into countless smaller tributaries, irrigation diversions, and other waterways. Many millions of dollars have been spent for the stabilization of channels and flood-control works in the Basin, but experience shows that many measures are too expensive or uncertain in results to be widely adopted until further study has been made.

Recommended research.---A thorough review of all the methods which have been used for the stabilization of channels is required. Research will be directed at the amount of sediment from channel-bank erosion on small to moderate-sized streams and the damage these deposits do to farmland, roads, and other structures. The types of structures effective in holding channels in their courses with least cost and with least chance for meandering and future cutting need investigation.

## How Flowing Water Moves Sediment

More knowledge of the basic mechanics of the movement of sediment by water is needed. Attempts to solve the problem during the last half-century have been based largely upon inadequate trial and error methods. Progress in controlling sediment-laden flows and in the general field of erosion control can take place only with a clear understanding of the laws of sediment transportation.

Recommended research.---The basic mechanics of sediment movement will be studied. This includes the relationship between the amount of material suspended and the shape of the channel cross-section as well as the roughness of the bed, banks, and walls. The U. S. Department of Agriculture will collaborate with outside research agencies which likewise are interested in this problem.

## Evaluation of Benefits from Reduction in Flood and Sediment Damage

Improved standards and methods for the economic evaluation of measures designed to slow down reservoir siltation are needed. Silting cannot be stopped completely, but the rate can be reduced and the useful

life of reservoirs thus extended. The benefits of longer usefulness in reservoirs will indicate the justifiable costs which can be incurred to accomplish this result alone.

Swamping, sediment deposition, streambank erosion, and gully formation constitute a major share of the preventable land damages. Improved methods for the economic evaluation of the benefits from preventing such damage need to be developed.

Recommended research.--Studies will provide information on the rate at which the economic life of reservoirs is likely to be reduced, on replacement possibilities and costs, and on changing costs of proposed structures under varying conditions of siltation. For land subject to damage economic studies will include the productivity of such land, the share of the income attributable to the land, the years of usefulness added by watershed treatment and flood-control measures, costs of reclamation for agricultural uses, and the rate of deterioration on lands subject to such damages.

## IRRIGATION DEVELOPMENT

### Snow Surveys and Water-Supply Forecasts

Snow surveys of very general coverage now exist on most major tributaries of the Missouri River. Snow-survey records in the Basin date from 1919, but observations at 90 percent of the existing snow courses began after 1935. These surveys provide a general guide to the expected annual water supply for the larger reservoirs, areas of irrigated land, and some established hydro-electric power generating stations.

Extension of the snow-survey network is needed to assure more detailed and reliable forecasts of streamflow to existing projects and to smaller sub-stream basins. Snow records are particularly needed from less accessible mountain areas which can now be reached with the available mechanized equipment.

Individual farmers and groups of farmers organized in irrigation and other districts need forecasts of water supply to help in planning land and water use and cropping programs on lands of all kinds, from the headwaters meadow or hay lands to the croplands of major valleys below.

An extended snow-survey network is also required for detailed and reliable forecasts of streamflow for water control and water-use projects not yet constructed. At least ten seasons of records on snow courses are essential to provide a reliable index to streamflow. Therefore, it is important that snow surveys be initiated several years before the construction of such water-control or water-use units.



Recommended research.-- These needs can be satisfied in a large degree by expanding the existing snow-survey network to all individual basins and sub-basins in Colorado, Montana, South Dakota, and Wyoming. Surveys will be made monthly beginning January 1 and ending May 1, as needed, to establish the snow-cover runoff relations for the unit areas. Wherever possible, snow surveys will be mechanized.

Planning the extended network will first require analyses, by sub-basins, of existing snow-survey records to learn the degree of correlation each year between measured snow cover and resultant stream-flow. As these analyses go forward, less time and money will be required for planning the network, but equivalent amounts will be needed to install the snow courses. The project, for the most part, will pass from planning to operation within 3 or 4 years.

#### Water, Soil, and Plant Relationships in Crop Production on Irrigated Lands

The introduction of irrigation into the central and eastern part of the Missouri Basin will create problems that have not been encountered in other irrigation projects in the United States. Until now, most of the irrigation has been confined to soils in arid and semiarid climates. Land leveling always impairs productivity, at least temporarily, where the topsoil is removed, but leveling does not impair many desert and alluvial soils as seriously as it will many of the strongly-developed soils of the Basin, where irrigation is not now generally practiced. Furthermore, much of the proposed irrigation is in glaciated areas which have irregular topography, where the distribution of water and drainage is difficult and where salt-bearing substrata lie at varying depths.

Most of the central and eastern parts of the Basin is in a climate in which, in many years, enough rain falls during the growing season to produce fair yields without irrigation. In such a climate, only part of the water required for plant growth will be supplied by irrigation because rainfall provides much of the needed moisture. Alternate wetting of soils with irrigation water containing certain salts and with salt-free rain water will cause poor soil tilth and reduce the rate of water infiltration and may so greatly reduce permeability that internal drainage will become impracticable. Studies are needed in regard to the amount of water required for irrigation and the times when water should be applied under these conditions.

In many places, rolling topography and thin soils make leveling impracticable. Furrows and gradual borders are hazardous because rains of high intensity may come at any time. New methods of applying water, including sprinklers, will have to be investigated and existing methods modified to meet the conditions prevailing in the areas proposed for irrigation.



Many soils proposed for irrigation are not naturally well drained. Adding many inches of water each year to the natural rainfall will overtax the natural drainage, and water-logging and alkali accumulation will result. This will be true both on rolling lands, where the natural depressions will fill with water, and on the extensive flat reaches where surface drainage is already a problem.

Some surface and ground waters contain excessive quantities of salts. For this reason, the problem of water quality is extremely important in avoiding saline and alkali soil conditions. Adequate drainage is required to prevent the accumulation of salt and to reclaim saline areas. Handling saline and alkali conditions is made difficult by impermeable subsoils and difficult drainage conditions and by the salts in some of the underlying geological materials, such as the Pierre shale and many of the glacial deposits.

The best cropping systems and soil management practices to use on many of the proposed irrigation projects are not known. Irrigators cannot afford to use costly trial and error methods to find the best cropping systems and soil management practices. They need this information beforehand, thus shortening and easing adjustment to irrigation farming. Relatively little research has been done on soil management problems under irrigation in subhumid areas.

Recommended research. Plot and field research is needed to learn with accuracy the requirements in regard to irrigation water, best methods of irrigation and water application, the drainage, soil moisture, and fertility relationships, best soil management and cultural practices, and crop adaptation. The field investigations will be carried out mostly on "development farms" with a gradual increase in cooperative experiments on typical farms in different areas. On these development farms, sufficient acreage will be available for representative farm-unit operation, thus serving as a farm-sized demonstration of the basic principles and relationships developed in the research program as well as furnishing an opportunity to work out on a field scale the application of the results of research. This field program will be supported by intensive laboratory research.

### Economic Problems

#### Market outlets for products grown under irrigation

Prospective increases in production in the Missouri Basin, even though they are spread over many years, require careful planning to assure the development of adequate marketing facilities as well as to integrate the production, especially from newly irrigated lands, into the national supply of farm products. Research is needed on potential market outlets, market development, and marketing facilities.

Recommended research.--Research will include a careful appraisal of market prospects and market facilities for various crops. Studies of needed storage and warehouse facilities, modern and low-cost processing facilities, and adequate transportation facilities will be made to aid producers and marketing agencies in performing the task of moving their products to consumers at the lowest cost consistent with high quality. The varying effect of potential increases and decreases in the production of commodities under authorized government loan and support programs will be analyzed in order to help farmers balance their output in keeping with production programs.

#### Development and settlement of irrigated land

A large number of farmers will change their operations from extensive dryland farming to intensive production under irrigation. Many farms will be subdivided and excess lands will be sold for new farms. As development of land for irrigation is costly, it should be planned and carried out to reduce both the original cost and subsequent operating costs. Land costs, development costs, and water charges must be kept within the ability of long-term earnings and repayment possibilities. In many areas, farm and non-farm population will be increased.

Recommended research.--Research will include investigations of farm development costs and the economy of rapid development as compared with the usual slow development over a period of years. Similar studies will be directed at alternative repayment arrangements, the relative advantage of various alternative areas for irrigation, costs and returns from different methods of applying irrigation water, and the extended benefits of irrigation in population increases, industrial growth, increased business activity, and public services. The means of obtaining maximum stability for farmers, agricultural production, and local government and institutions, and appropriate leasing and tenure arrangements for irrigated farms will be studied.

#### Sizes and types of farms likely to succeed under irrigation

The subhumid areas, where most of the irrigation development is proposed, are already being farmed in large units with mechanized equipment. Irrigable acreage in these areas is interspersed with and surrounded by nonirrigable acreage which will continue to be farmed without irrigation. If irrigated farming is to succeed in, such areas it must be developed in sizes and types of farms which will enable farmers to pay development and operating costs, integrate irrigated and dryland farming in the same operating unit, and utilize as far as possible the equipment and facilities already in the areas. Experience in irrigation farming in the arid and semiarid areas cannot be applied in such areas.



Recommended research.--In order to determine the sizes and types of farms most likely to succeed in the areas to be irrigated, the income expectancies of such farms and the farm practices and uses of water adapted to each area will be studied in three distinct phases of research. The first is an appraisal of the current pattern of agriculture in the areas to be irrigated, including a determination of sizes and types of farms, the amount and productivity of both irrigable and nonirrigable acreage in each, dryland yield expectancies, and the availability of buildings, livestock, and equipment adapted to irrigated farming. Accompanying it will be an appraisal of irrigated farm investments, practices, labor requirements, and yield, income, and cost expectancies by size and organization of farm and by soil groups. These data are needed from established irrigated areas with physical and climatic characteristics as nearly as possible like those of the areas to be developed and from all other available sources which will throw additional light on irrigation's problems and probable responses in the areas to be developed. The third phase will be an interpretation of the assembled data in order to provide for each of the major soil groups in the development areas the best obtainable estimates of the yield, cost, and income expectancies and the investment and labor requirements for various sizes and types of farms.

#### Agricultural output and prices under irrigation

Although approximately 5 million acres are now irrigated in the Basin, only very limited data are available on acreage, production, and yield of crops on irrigated and nonirrigated land separately. Likewise, little information is available on livestock numbers in irrigated areas. Cropping and livestock management problems and recommended practices are entirely different in and for irrigated and dry farming. The benefits from irrigation development can be measured only by reliable statistics on crops grown under irrigation.

The relationships between irrigation contract payments and farmers' ability to repay and between credit repayments and ability to pay have varied because of fluctuating farm incomes. Part of this fluctuation in income is due to changes in prices farmers receive for their products and to changes in prices they pay for living and production items. Prices received and prices paid by farmers and ranchers in the irrigated areas of the Basin are not covered by any State index now in existence. The construction of such indexes is a prerequisite to the development of a sound plan for annual variations in irrigation or credit repayments.

Recommended research.--These data are needed early in the development program. Basic information will be collected and estimates will be prepared for acreage, production, and yield of various crops grown on irrigated and nonirrigated land. County estimates of livestock numbers will be improved to permit developing livestock statistics for the irrigated areas in the Missouri Basin. Indexes will be prepared for prices received and prices paid for irrigated areas of each State.



Existing data will be buttressed by local records and surveys. Price indexes for irrigated areas will begin with 1937 and will continue monthly, thus providing a price series for immediate use.

### Capital requirements and credit for irrigated farms

The shift to irrigation will require large amounts of capital on many individual farms. There will be a heavy capital requirement for the purchase of land in many cases. Frequently large outlays will be needed for leveling and adapting the individual farm for use of irrigation water. New and renovated farm buildings and homes will be required and heavy expenditures will be needed for machinery and livestock. In addition, there may be fairly high costs in taxes to pay for the community facilities that are involved in an irrigation project. These requirements will be much greater than the average farmer is likely to be able to meet without credit. In the past, credit facilities have not been adequate to finance these total capital needs. The result has been, in many instances, that full-scale farm operation and full income were only realized after years of sacrifice and distress for the farmer and his family.

Recommended research.--To facilitate development, studies will be made of such problems as more accurate determination of the capital requirements of farmers and ranchers, re-examination of the basis upon which the developments proposed in this report can be financed soundly, and determination of what modifications of credit facilities, if any, may be needed to assure adequate credit service.

## DRAINAGE DEVELOPMENT

### Drainage Requirements in Relation to Soil Types and Land Use

In the eastern part of the Missouri Basin, large areas of comparatively flat land, shallow sloughs, and stream bottoms require artificial drainage before they can be cultivated to the best advantage. Some areas have heavy or claypan subsoils which increase the difficulty of drainage. In the Great Plains, during years of average or above-average spring rainfall, crops frequently cannot be planted in time to mature before frost. The problem is to determine drainage requirements under a wide range of soils, climate, and land use and to develop effective methods of drainage under such conditions.

Recommended research.--The research will undertake to determine the type of drainage needed for different types of land, such as light prairie soils, heavy bottom lands, and uneven topography in nearly

level areas of the Great Plains. The feasibility of surface and under drains for different localities will be studied along with the spacing and size of tile drains. The relation of land use to the system of drainage is another general field of research.

#### Economic Problems of Drainage Development

Many drainage enterprises have encountered economic difficulties in the past. In some cases, farm land has been foreclosed to satisfy bondholders. More often areas have experienced general financial distress which results in a poor credit rating for the farms in the enterprise. As levees for flood protection are installed along the main rivers, local drainage districts will face new problems.

Recommended research.--Economic studies will be made of drainage methods, types of organization, types of land involved, costs and returns, and methods of repayment.

#### RESEARCH OF IMPORTANCE TO ENTIRE PROGRAM

##### Weather-Tolerant Plants

The development of land resources in the Missouri Basin may be helped as much by growing the right kinds of plants as by irrigation and flood control. Unfavorable aspects of weather may be the principal cause of reduced yields and crop failures on irrigated land as well as nonirrigated. During the 10 years prior to 1939, an average of 14 million acres of wheat was abandoned each year because of drought and high temperatures. Winter-killing limits winter wheat mostly to the southern half of the Basin and in some years causes heavy losses even there. Every year, crops are damaged by shortage of water, high temperatures, low temperatures, and wind. Furthermore, some insect pests and plant diseases are worse under certain conditions of weather.

Farmers as well as scientists have known for a long time that some plant varieties are more resistant to extremes of temperature, moisture, and wind and to diseases and insects. Much of the plant-breeding and selection work has been directed towards getting resistant varieties. Without that research, some important crops now grown probably would have disappeared from the Basin long ago.

The farmers of the Basin need crop varieties more resistant to drought, high temperatures, strong winds, insects, and diseases. Farmers in irrigation projects also need varieties of high-value crops most resistant to weather hazards. In the drier parts, more suitable legumes are needed.



Recommended research.--A central laboratory is recommended, including greenhouses and controlled temperature, light and humidity chambers, where plants can be subjected to artificially produced conditions of weather and soil. Here will be studied the histology, physiology, and chemical composition of plants of different species and varieties to determine what characteristics are responsible for differences in tolerance to unfavorable conditions, the factors that favor disease-producing organisms, techniques for ascertaining the resistance to unfavorable conditions, the interrelations between tolerance of varieties to different environmental conditions -- for example, between resistance to high temperature and deficient soil moisture. The research will be directed at the effects of temperature, sunlight, and other factors involved in acclimating plants, the resistance of species and varieties of domestic and foreign origin to high and low temperatures at different stages of growth, and the ability of species and varieties to grow at low temperatures for winter grazing. The results and the material tested in the laboratory will be used by State Agricultural Experiment Stations in their programs of plant breeding and field trials.

### Insect Control

Insects cause much damage to farm crops and grasses in the Missouri Basin and, to some extent, encourage wind and water erosion. Grasshoppers and other pests sometimes greatly lower the yields and consequently the farm income. Other insects reduce the profits on ranches by their attacks on livestock. Moreover, insects are one of the important reasons why development and maintenance of forests is difficult in the Basin. From time to time, attacks of the mountain pine beetle, the Black Hills beetle, the spruce-bark beetle, and the spruce-budworm cause extensive kills in the forests of pine, fir, and spruce.

The irrigation and cropping of extensive areas have always caused new insect problems and intensified existing ones. If more effective means of dealing with several of these pests are not developed and known methods of fighting others are not adapted to the conditions prevailing in the areas, heavy losses may be expected. The basic cause of severe outbreaks of insects is not well understood.

One of the foreseeable needs in the development of new irrigated areas is an adequate supply of pollinating insects.

Recommended research.--Insect research laboratories are recommended at three or four strategic locations. Each will be supplemented by outlying experimental work on methods of controlling harmful insects and utilizing beneficial ones. Research will be designed to discover the causes of periodic outbreaks of insects. Ways of eliminating mosquito-breeding conditions in impounded water and in irrigation and drainage systems will be studied.



### Farm Machinery

New types of farm machinery are needed to apply soil and water conservation practices and attain increased production on irrigated and nonirrigated lands in the Basin. Widely varying climatic and soil conditions will require different types of equipment. Some implements have been invented or adapted that are particularly useful under Missouri Basin conditions. For example, experimental work done with equipment for use in stubble-mulch farming has resulted in the development of several types of machines superior to those previously used. However, more study is needed to determine the various kinds of implements necessary for the many different cultural problems encountered in the Basin.

Recommended research.--This problem will be studied at a central laboratory established at one of the Agricultural Experiment Stations in the Basin. Fundamental studies of the design and experimental construction of machines for the different cultural problems can best be made at the central laboratory. The laboratory will cooperate with each of the States in testing the equipment under local conditions.

### Farm Methods Engineering for Efficiency in Use of Labor and Power

Prospective changes in farm enterprises and operations will increase demands for building and farmstead plans, improved equipment, and operating methods which will permit a more effective use of labor, electrical and other power, construction materials, and other resources available to farm families. From 20 to 80 percent of all farm labor is used on the farmstead, depending upon the type of farming. Surveys and limited research indicate that more efficient use of labor on the farmstead can be obtained by the orderly development of efficient combinations of power, equipment, and buildings. The wide acceptance of rural electrification provides a challenge to use this newly available, versatile form of power to the greatest advantage on the farmstead and in farm operations.

Recommended research.-- Basic investigations, field studies, and pilot operations will be devoted to the varied aspects of farm engineering. The functional and design requirements of farmsteads will be analyzed, taking into account size of farm, diversity of enterprises, and available markets. The research will appraise the basic requirements for structures and equipment directed toward improved systems of production from crop to livestock to market and the most effective equipment for handling, conditioning, and storing feed crops and products on the farm and transporting them from farmstead to market. Important contributions to farm living will come from research which will study the improvement of farmstead water supply and waste disposal systems, giving consideration to irrigation uses, livestock requirements, sanitation,

fire protection, and human convenience. The effective use of electrical energy on the farm, in proper balance with internal combustion engines in the field and on the farmstead, also will be explored. Other research will be directed at combinations of engineering techniques which will enable the farmer to plan his marketing for a definite period, to market at his convenience, and to market products of the highest quality.

### ESTIMATED COSTS

The program outlined above is in addition to the research activities now being carried out in the Basin and is designed to meet the special problems of the Basin development program. The estimated cost of the additional program of research and investigations set out in the foregoing is shown in the following tables. Table 31 shows estimated federal cost for installation of research facilities and for operating for a 10-year period. The table also shows the breakdown of estimated costs between the various classes of work described above. The estimated contributions of the State Agricultural Experiment Stations are shown in table 32. The amount of contribution from the Department and from the States will vary, depending on the particular project. In many cases work done at one location will be useful in several States. Maximum use will be made of joint State-federal cooperation on Basin-wide projects, with individual States or the Department contributing more to one than another, but each sharing the benefits from all the research. Research primarily for the purpose of improving the management and use of federal lands will be financed with federal funds.

The estimates encompass research of high priority needed to meet the problems arising with the initial phases of the development program. In addition to annual adjustments and before the end of the first 10-year period, the program will be completely reexamined and reevaluated in order to meet the needs of the second 10-year period. After the completion of the accelerated research program, the various activities will be appraised and adjusted to a level more in line with the maintenance requirements of management and conservation practices of the Basin.

### CONTRACTS

It is recommended that the Secretary of Agriculture, in accordance with such regulations as he deems necessary and when in his judgment the work to be performed will be carried out more effectively, more rapidly, or at less cost than if performed by the Department of Agriculture, may enter into contracts with such public or private organizations or individuals as he may find qualified to carry on work under this program without regard to the provisions of Section 3709, Revised Statutes, and with respect to such contracts he may make advance progress or other payments without regard to the provisions of Section 3648, Revised Statutes. Such contracts may be made for work to continue not more than 4 years from

the date of any such contract. Notwithstanding the provisions of Section 5 of the Act of June 20, 1874, as amended (31 U. S. C. 713), any unexpended balances of appropriations properly obligated by contracting with an organization or individual for carrying out any part of this program may remain upon the books of the Treasury for not more than 5 fiscal years before being carried to the surplus fund and covered into the Treasury.



Table 31.--Estimated Federal Cost of Accelerated Agricultural Research  
Program - Missouri River Basin 1/

	: Cost : of : Installa- : tion Thou. Dol.	: Average Annual : Operating Cost : First : 5 Years Thou. Dol.	: Total Instal- : lation and : Operating Cost : 10 Years Thou. Dol.
<u>Conservation and management of farm and ranch land</u>			
Soil and water management	233	632	6,946
Improved legume and grass seed	250	70	1,092
Forage utilization	245	53	1,085
Economic research	--	130	1,125
Sub-total	728	885	10,248
<u>Forest and range research</u>			
Watershed management	950	340	4,350
Forest management	950	320	4,150
Range management	600	300	3,600
Fire control	--	170	1,700
Forest products	--	170	1,700
Forest economics	--	260	2,300
Sub-total	2,500	1,560	17,800
<u>Reduction of water run-off and sediment</u>			
Effect of land use on run-off and erosion	120	80	920
Control of reservoir silting	14	69	704
Channel stability and sediment movement	13	66	673
Mechanics of sediment transportation	67	50	567
Evaluation of benefits	--	30	250
Sub-total	214	295	3,114
<u>Irrigation development</u>			
Snow surveys and water supply forecasts	100	105	1,150
Water, soil & plant relationships	269	695	7,258
Economic problems	--	312	2,650
Statistics on irrigated land	--	244	2,020
Sub-total	369	1,356	13,078
<u>Drainage development</u>			
Drainage requirements in relation to soil and land use	120	60	720
Economic problems of drainage	--	20	175
Sub-total	120	80	895
<u>Research of Importance to the entire program</u>			
Weather-tolerant plants	475	81	1,430
Insect control	--	263	2,765
Farm machinery	370	88	1,360
Farm method engineering	--	57	615
Sub-total	845	489	6,170
TOTAL	4,776	4,665	51,305

1/ These estimates may be modified by the Secretary by shifting funds between major lines of work if needs require.

Table 32.--Estimated Contributions of State Agricultural Experiment Stations to Accelerated Agricultural Research Program  
Missouri River Basin

	: Cost : of : installa- : tion Thou. Dol.	: Average annual : operating cost : first : 5 years Thou. Dol.	: Total instal- : lation and : operating co : 10 years Thou. Dol.
<u>Conservation and management of farm and ranch land</u>			
Soil and water management	--	138	1,382
Improved legume and grass seed	--	64	631
Forage utilization	--	135	1,407
Economic research	--	113	1,086
Sub-total	--	450	4,506
<u>Forest and range research</u>			
Watershed management	--	--	--
Forest Management	--	--	--
Range management	--	--	--
Fire control	--	--	--
Forest products	--	3	30
Forest economics	--	4	25
Sub-total	--	7	65
<u>Reduction of water run-off and sediment</u>			
Effect of land use on run-off and erosion	--	15	148
Control of reservoir silting	--	17	175
Channel stabilization and sediment movement	--	18	180
Mechanics of sediment transportation	--	35	350
Evaluation of benefits	--	--	--
Sub-total	--	85	853
<u>Irrigation development</u>			
Snow surveys and water supply forecasts	--	1	10
Water, soil and plant relationships	--	228	2,280
Economic problems	--	230	2,260
Sub-total	--	459	4,550
<u>Drainage development</u>			
Drainage requirements in relation to soil and land use	--	32	320
Economic problems of drainage	--	7	70
Sub-total	--	39	390
<u>Research of Importance to the entire program</u>			
Weather-tolerant plants	--	64	631
Insect control	--	54	556
Farm machinery	--	45	450
Farm methods engineering	--	70	700
Sub-total	--	233	2,337
TOTAL	--	1,273	12,701

## PROGRAM OF EXTENSION EDUCATION

Rapid progress in development of the agricultural resources of the Missouri Basin is largely dependent upon the active participation of farm families and upon the active cooperation of farm groups, civic and commercial organizations, local, county, and State institutions, and governmental agencies. Participation and cooperation can be effected through wide-spread knowledge of objectives of the program, general agreement on the functions of all agencies, and the acceptance of both farm people and governmental agencies of the special responsibilities of each. This widespread knowledge can be established through educational means.

Full utilization of the facilities created by the Basin development program will be realized when the people living in the areas understand the scope of the program and the possibilities for a better standard of living it assures. It is particularly important that the people understand from authoritative sources how the proposed structures, changes in farming systems and practices, facilities to be made available, and other features of the development program will affect them personally, the community, the region in which they live, and the United States as a whole. This understanding, or the lack of it, is the key to the manner in which people in a democracy cooperate with their government in programs for the common good. It can be best established through educational channels.

The structures built for the purposes of irrigation and flood control will make possible many facilities which can be used to improve the agriculture and the living standards in the Basin. Agricultural agencies and institutions and farm people and their organizations have the responsibility for developing the best uses of the facilities thus made possible. Therefore it is of primary importance that each farmer study how the availability of water or electric current will affect his farm, and for each group of farmers who live on or adjacent to a construction project to study and determine the means by which that project can bring them the maximum amount of benefit and stability.

Phases of the development program involving changes of farm management, the adoption of new cultural practices, utilization of the by-products of conservation, such as hay or pastures, and other changes on privately owned land, including the manner of living of the people, are particularly dependent upon understanding the "why" of such changes if the proposed changes are to become established farm and home practices. This understanding can be attained most quickly through educational effort. Thus educational work is essential to any program that produces lasting results.

The educational program should precede and be kept in step with the developments of the various construction projects, land treatment, and other accelerated programs in the Basin. The people must



be constantly informed through contacts with official sources of information. This educational service should be available to all the 582,000 farm families in the Basin. In addition, urban people should be informed of the importance to them of the development of these natural resources.

### EDUCATIONAL PROBLEMS

There is a lack of general public understanding of the development proposals and appreciation of the inherent possibilities for increased income and improved living standards. Most people don't realize the adjustments in farming, range use, and forest land management that must be made to protect public investments in the new dams, reservoirs, and other structures and insure full and efficient use over a long period of time.

Educational needs are of three types: (1) To develop and to expand participation of farm and civic leaders working with representatives of all agencies in planning the development of the Missouri River Basin; (2) to assist farm people, ranchers and forest and woodland users to understand and adopt a wide range of new techniques of soil and water conservation and management extending from the upper mountain watersheds to the lower humid areas of the Basin; (3) to promote among rural people higher living standards made possible through more stable income, availability of electric current, more adequate diet through local production and use of more fruits and vegetables, and better facilities for health, recreation, and education.

### EDUCATIONAL ACTIVITIES IN RELATION TO ACCELERATED AGRICULTURAL PROGRAM

In order to contribute to meeting these and similar needs, the U. S. Department of Agriculture recommends the development of educational and service programs to be carried out with the cooperation and assistance of federal, State, and local agencies.

The prime essential is a general educational program to inform the people of the Basin of the proposed development and its likely effects upon their social and economic welfare.

This general effort must be buttressed by accelerated educational programs, some of a continuing nature, designed to inform farm and nonfarm people of the varied aspects of the development, encourage and assist farmers to adapt their enterprises to new conditions by using techniques which fit their new environments, and, in many particular instances, to give farmers the informational help they need to bridge the gap between the old and new in soil, water, farm, forest, and range management. New irrigation areas call for new and continuing educational service programs of special quality.

The benefits of the Missouri Basin development can be realized in full within a short time only if these educational efforts are capped by a program to improve living standards. Here the emphasis will be placed on the best use of new facilities and services in recreation, improving health, producing adequate food supplies, increasing the comfort and attractiveness of farmsteads and homes, and utilizing labor-saving devices. In this way, the Basin development can bring more satisfactory living.

In general, the recommended educational programs will be accomplished in three steps. The first, of course, is planning with farmers and agency representatives how farm families can best use their own efforts and available assistance to improve farming and living situations. This should be followed by the educational efforts needed to help farm people to put these plans into operation and, then, to utilize the benefits of the Basin development in better living.

#### Conservation in General Farming and Range Areas

The largest part of the educational program is gaining full acceptance of adapted soil and water conservation practices. Even with the full development of irrigation possibilities, the main problem in vast areas is to conserve water where it falls in order to increase yields, control erosion, and reduce flood runoff. Certain of these areas have been designated as high risk areas because of recurring crop failures. Research and experience have found that much of the risk can be avoided by the use of adapted crop varieties and practices. Consequently, some crops can be produced even in unfavorable years. Many of the problems of obtaining a more sustained production in much of the upper Basin may be solved by adapting crops and practices to the climate of the region.

An illustration of the features of the agricultural program that must be supported by extension work among farmers is good management on watersheds to assure high quality water and to prevent silting. This is a vital part of river basin development. The forage resources on the forest ranges and adjoining ranges are of the utmost importance. Extension education can encourage the adoption of management practices which can add to the material prosperity of the Basin. Improperly managed or abused, these resources constitute a liability. Thus carrying out soil and water conservation practices is required on the upland areas.

Soil and water management for economic crop production calls for readily available information on the use of crops and varieties which research and experience have found to be best adapted, the value of conserving organic matter in the soil as a means of preventing erosion and aiding water absorption and retention, increasing yields through conservation of each additional inch of moisture in the soil, and the increased importance of controlling weeds where moisture is a controlling factor in crop production.



Education in proven methods of preventing wind and water erosion should be accelerated in keeping with other phases of the Basin development. Special emphasis is required in critical erosion areas, particularly those in northwest Missouri, northeast Kansas, eastern Nebraska, western Iowa, and southeastern South Dakota, where soil losses due to erosion are very heavy in high-producing farm areas.

Approved techniques of draining agricultural lands should be translated into farm practice to fit the conditions that created the problem. These include the inundation of fertile valley floors when floods overtop stream channels, runoff from higher farm lands, and inadequate drainage caused by soil and topography.

Control of insect damage, the need for reserve feed supplies, and shelterbelts and windbreaks are subjects with a high educational priority rating in the accelerated program.

As the program progresses, certain by-products will be developed to which educational assistance must be applied if they are to achieve full usefulness. These include the utilization of increased supplies of hay, forage, and pasture through livestock as an essential adjunct of soil and water conservation.

### Forest Resources

Forest resources are somewhat localized in the Basin, but they are important to the welfare of all the citizens of the area. Watersheds important in terms of water yield are primarily forested or forest range lands. The proper management of these lands is basic to obtaining a well-regulated flow of usable water in the future. The production of forest products for consumption in the Basin can aid in meeting the requirements of farmers for building materials, fence posts, lumber, and boxes, and the manufacture of lumber and other wood products can form the basis of industrial activity supplementing agriculture. Other forest resources, primarily recreation and fish and game, also contribute to better living.

In the hardwood areas in the eastern portion of the Basin, education can aid in the task of improving the quality of the woodlands through better care and use of this resource. Here crop lands and woodlands are generally intermingled and constitute inseparable parts of a complex land use pattern. The whole level of rural living can be improved by integration of woodland management with other farm enterprises.

A Basin-wide educational program is recommended to help realize the full benefits of forest and range resources. This must reach all citizens, urban and rural residents alike. Many of the recreationists and hunters making use of the forests and woods are city folks. Especially must there be an adequate program to reach forest and range land owners and operators to stimulate their interest in



carrying out better management practices. Proper and full information is a prerequisite to the conduct of a satisfactory program of public forest and range land management. The educational program will be most effective if technical guidance and assistance are available to aid landowners in carrying out the accelerated program of good resource rehabilitation and use.

### Irrigation

Under the development program, about 6,000,000 acres of land will be brought under irrigation, and thousands of farmers in these areas will need to learn a new type of agriculture. Many of these farmers will need to adjust their present dryland farming to irrigation and to combinations of dryland and irrigation. The transition will involve problems of utilizing new crops, including new vegetables and fruits, as well as organizing and utilizing such community services as electric power.

The educational program in areas to be irrigated is designed to meet the needs in three stages of development: (1) Planning and pre-construction, (2) development and settlement, and (3) the post-development period.

The first stage will bring to the people information based on research and the experience of irrigation farmers in other areas concerning the adaptability of the area for irrigation, probable cost and benefits, and adjustments in farm and living situations. This includes probable market outlets for irrigated crops and similar information on which judgments may be based. The second stage will require more detailed information on soil and water management problems, water requirements of major crops, market outlets for new products, and problems of farm management and home management under irrigation farming situations.

Educational work in the third stage of development is particularly important in order that the whole community may fully utilize the opportunities for a balanced and more stable agriculture and better living. Moreover, the public and community investment in dams, electric lines,, irrigation ditches and other construction must be safeguarded. The farm people of these areas should be kept abreast with improvements in crop varieties and cultural, farm management, marketing, and other farming and homemaking practices which are being developed by the expanded research program.

Many families, including several thousand who will be forced to move from reservoir areas, will need information about new locations where they will find opportunities to establish themselves. Among the first essentials is to bring these families and communities into contact with officials who can give authoritative information. Irrigation developments will afford opportunities for many new families. The educational program will place families needing to relocate in touch with the opportunities to acquire new farms thus

created.

The proportion of acreage now operating or proposed to be developed under small irrigation projects of 1 to 24 farms is 59.3 percent of the total irrigated land in the Missouri Basin. These small projects involve many of the problems inherent in major projects and have some additional problems peculiar to small enterprises. These include poor distribution systems, incomplete land development, limited supply of water, inadequate maintenance, and the need for technical services in organization, finance, legal procedure, and engineering.

Educational assistance and often technical and financial help in each is essential in stabilizing the agriculture of the area and providing satisfactory farm living situations for a greater number of people. Individual farmers and small groups of farmers not only can draw upon the available educational assistance, but they will be aided in locating sources of technical and financial help.

There are irrigation areas now in operation where special educational help is needed and will be given in farm and home planning and management. Some of these present critical problems. Supplying this information and placing these people in touch with sources of technical and financial assistance will be imperative if projects are to become solvent, farm families maintained on them, and the investment protected.

Integrating irrigation farming with surrounding types of farming, in terms of opportunities and results, needs a clearer understanding. The crop diversification and the stabilization of livestock production which can be obtained through the combination in one farm of irrigated and non-irrigated land can be determined from experience and by research. Some of the "development farms" proposed or now in operation can test recommendations and serve as educational demonstrations. As sounder types of diversifications are explored, discussions can be initiated in areas where irrigation development is expected so that farmers will have the chance to evaluate various combinations as they plan the change over to irrigation farming. Tours will be conducted to experimental sites such as the Tri-County area, south central Nebraska, where farmers are now trying out several combinations of irrigation and dry-land farming.

#### Supporting Programs

An educational job of great importance lies in supplying information concerning such supporting programs as research and credit. The research program will continually make new information available. This will be disseminated through the educational program to farm people and other interested parties as rapidly as available. Farm people will be assisted in applying research findings to their particular problems. Educational work in relation to credit will familiarize farmers and ranchers with sound credit procedures,



credit management, safe credit loads, types of credit available and their advantages and disadvantages, sources of credit, and similar matters.

Assisting People to Realize Better Living Standards  
and Farm Efficiencies

The extension of electric power to many rural communities is bringing new services to farm families in the form of many desirable conveniences. As new sources of electric power become available, families will need information on bringing water into the house, sewage disposal, electrifying the farmstead, and the selection and care of electrical equipment. In obtaining these improvements, some families will need assistance in financial planning.

Increased industrialization will come about as sources of new electric power are developed. This will directly influence the living standards of rural communities. Expansion of industrial centers will provide local market outlets for farm produce. It is equally important that this industrial expansion will provide an outlet for employment of farm youth. Also the cost and services of improved health centers, recreational centers, and educational facilities will be shared by both rural and urban people.

Many families are now asking for help in evaluating plans for new houses, remodeling old ones, or reorganizing the entire farmstead. Increased local production of fruits and vegetables under irrigation will make possible a more adequate diet. Better health will result.

More stable income and increased population in some areas will make possible better recreational, health, school, and communication facilities. Educational support will be given to helping people utilize these and other by-products and to assisting the people to organize to obtain these facilities.

EDUCATIONAL METHODS TO BE USED

The educational programs will be planned with rural people in the particular area concerned and with the representatives of agencies cooperating in the agricultural program. It is important that all available means be utilized to carry information and educational assistance to the particular groups to be reached as well as to the public as a whole. More general information and recommendations will be brought to the people concerned through the press, radio, circular letters, meetings, farm visits, discussion groups, and in other ways. Farm people will be assisted to make adjustments in farm operations and family living through small meetings, farm visits, tours to older developed areas and to experiment

stations, demonstrations and nearby farms, and similar channels. Particular effort will be made to assist farm people to develop farm plans to correlate on their farms the recommendations in various technical fields.

#### ESTIMATED PERSONNEL REQUIREMENTS AND COSTS

There are now cooperatively employed with the Land-Grant Colleges and the 440 county governments in the Missouri River Basin some 474 men and 257 women giving practically full time to voluntary educational programs concerned with improving agriculture and homemaking practices. This staff in most instances is fully employed with current programs. The accelerated educational program here recommended will require an additional 400 county agricultural agents, 100 home agents, and 60 specialists. These additional persons will be employed gradually over a period of 10 years, starting with 145 in the first year of the program. The first specialists employed should be in technical fields which will contribute most to the irrigation and erosion control features of the program, such as agricultural engineers, soils specialists, and foresters. Specialists in fields which will enable people to take full advantage of the new facilities created to stabilize farm income and improve living standards through livestock, marketing, and home management should be added as the program develops. Agricultural agents should first be added in counties where erosion is critical and in areas where new irrigation projects are being developed. They should be gradually added in other less critical areas where the present staff are unable to carry the accelerated load and where impacts of the construction phases of the development affect the farm economy and living standards.

County home agents will be added first where the new developments affect the living situation, particularly with respect to housing, use of electricity in the home, health with particular respect to diet, and living costs in relation to farm income during and following the development period. The additional staff recommended will be supervised by the present supervisory staff and housed in present county offices.

Estimates of the personnel required to carry out the recommended program are summarized in table 33. Estimates of costs also appear in table 33.

It is recommended that the Secretary be authorized to carry out in cooperation with the States the types of educational work outlined herein, and that the funds required to supplement the staff available under existing authorizations shall be allotted by the Secretary to the States in such amounts as he deems appropriate.



Table 33.--Estimated Personnel Requirements and Costs for the  
Program of Extension Education

Year of Operation	Number of Specialists	Number of County Workers			Cost Estimates		
		Agri.	Home	State	Federal	Total	
1	15	100	30	\$	\$ 796,500	\$796,500	
2	25	150	40		1,191,500	1,191,500	
3	30	200	50	154,900	1,394,100	1,549,000	
4	35	250	60	190,550	1,714,950	1,905,500	
5	40	300	70	339,300	1,922,700	2,262,000	
6	45	325	80	372,150	2,108,850	2,481,000	
7	50	350	85	535,500	2,142,000	2,677,500	
8	55	375	90	574,800	2,299,200	2,874,000	
9	60	400	95	767,875	2,303,625	3,071,500	
10	60	400	100	773,500	2,320,500	3,094,000	
Each year after tenth	60	400	100	1,000,000	2,094,000	3,094,000	
Thirty-year cost.....				\$23,708,575	\$60,073,925	\$83,782,500	

### A SUPPORTING CREDIT PROGRAM

The accelerated agricultural program for the Missouri Basin will call for large capital investments. Although the federal government will make a substantial contribution in the form of technical guidance and incentive payments, a major part of the cost will be borne by farmers individually and as members of groups. A considerable number of farmers, however, will lack sufficient funds of their own to participate in the program to the extent that they desire. These farmers will have to rely on credit.

A considerable amount of loanable funds will be available from existing credit sources on suitable terms and conditions, and these sources should be utilized as far as possible. However, the type of development and readjustment credit required by many farmers will not be available under the standards and authorities of present lenders. In some cases, the amounts of credit available to particular individuals and farmer groups will be inadequate for such purposes, because legal limits exist on the maximum dollar amount which may be loaned, appraisal procedures will not permit sufficient recognition of future earnings expected from proposed farm improvements and readjustments, or the applicants lack equity in assets acceptable to lenders. In other cases, the terms and conditions available are unsuited for such purposes because the required repayment period is too short, repayments on principal cannot be deferred during the development period, or the repayment schedule is too rigid in view of conditions causing wide variations in annual income. In still other cases, the total supply of loanable funds available to some lenders is insufficient where the need for credit for farm improvements and readjustments is most acute. Therefore, supplementary credit facilities should be available in any area of the Basin where the present credit facilities are inadequate to provide the funds necessary for farm development and the readjustment of farming operations to place the farm business on a sound basis.

A sound credit program should be based upon a careful evaluation of the proposed capital outlays and their effect upon future income. This evaluation is particularly important in developmental and readjustment credit since the risks are somewhat greater than those encountered on farms where production and marketing have become standardized and stabilized. These risks can be minimized, however, by carefully worked out farm and home plans, by appraisal procedures which recognize the future benefits from planned developments and adjustments, and by furnishing technical guidance and supervision to the borrower.

In order to facilitate the proposed development, the agricultural credit program must recognize all the purposes for which capital will be required by farmers who will participate.



## PURPOSES FOR WHICH INDIVIDUALS WILL NEED CREDIT

### Farm Acquisition

One important purpose for which funds will be needed is acquisition of land. An estimated 18,800 new farms created by irrigation will be available to new owners. Furthermore, throughout the region some farmers will desire to purchase additional land in order to bring about adjustments necessary to achieve economic operation.

### Farm Improvement

A substantial amount of funds will be needed for the major improvements required on many farms. Both existing owners and new owners in irrigation projects will need to level land, install pumps, construct ditches, provide facilities for drainage, and make other similar improvements.

Within established irrigation areas, 6,500,000 acres can be made more productive by rehabilitating existing irrigation systems, land leveling, drainage, and similar improvements. Likewise, several million acres of wet land require rehabilitation of existing drainage systems and construction of new facilities.

Many farmers will need credit to finance the land treatment measures described in this report. For example, about 2,000,000 miles of terraces and 431,000 miles of grassed waterways are major items in the program. Other measures calling for important investments include conversion of cropland to grass and trees, application of lime and fertilizer, installation of stock watering facilities, and construction of water diversion and check dams for gully control.

New and improved farm buildings represent another major purpose for which funds will be needed to complete the development of a large number of farms. In addition to buildings, there will be other permanent types of farm and home equipment that will be required, such as electrical equipment, fences, and domestic water facilities.

### Farm Operations

New or additional working capital will be needed in substantial amounts on many farms where major development or adjustment programs are contemplated. Purchasers of new irrigated farms, for example, will require livestock and a line of machinery adapted to the production of irrigated crops, funds for running expenses, and feed and seed to get established.

## PURPOSES FOR WHICH GROUPS WILL NEED CREDIT

There will be a number of phases in the Basin development and improvement program that can be accomplished most effectively by farmers when

organized for group action. Credit will be required in financing many of the following activities.

### Water Facilities

Some of the water facilities needed for irrigation outside of the main developments will be community projects operated by water users' associations and irrigation districts. Some existing irrigation projects need more adequate supplies and improved distribution systems to utilize fully the water now available. Drainage works often require repair to restore productivity to presently irrigated areas. Frequently, domestic water can be supplied most economically through community installations.

### Soil and Water Conservation Facilities

Soil and other conservation districts have been organized to provide a group attack on the land treatment program. Installation of some soil and water conservation measures and practices require special heavy equipment not always readily available to the individual farmer. District purchases of such equipment and other facilities will promote the more rapid attainment of the Basin program.

### Marketing and Processing Facilities

The development of large new irrigated areas will require the establishment of new and expanded facilities for the marketing and processing of farm produce and the purchasing of farm supplies. In some instances, these facilities will serve the interests of farmers better if cooperatively owned and operated by farmers themselves.

## RECOMMENDATIONS

It is recommended that the Secretary of Agriculture be authorized to carry out in the Missouri Basin, through the facilities of the Department of Agriculture, State Land-Grant Colleges, Universities and other cooperating public and private agencies, a program of furnishing credit and technical guidance and assistance to individuals and farmer groups as hereinafter provided, such authority to be in addition to and not in substitution for any existing authority of the Secretary.

### 1.

Existing credit facilities shall be used to the maximum extent possible, as follows:

- A. Encouragement and assistance shall be given to private and cooperative lenders to finance to the fullest extent possible, consistent with sound business practices, farmers in need of credit for development purposes. Such encouragement and assistance may be by:



1. Referral of applicants for loans to private and cooperative lenders.
  2. Furnishing guidance and technical assistance in the making of appraisals and in evaluating the credit needs of farmers to private and public lenders that desire to advance credit to farmers for farm development and adjustments in farming systems and to farmers' groups for various kinds of community facilities. These services shall be available for such fees as may be determined by the Secretary.
  3. Informing private lenders of the objectives and procedures pertaining to the Basin program in order that they may adapt their operations as far as practicable to the needs created by the program.
- B. The national farm loan associations, production credit associations, and banks for cooperatives will continue to operate in the Basin within the scope of their existing authority, and they will be encouraged to adapt their practices to the extent practicable in order to meet the needs of agricultural development on a sound basis.
- C. The Farmers Home Administration, without regard to present limitations in the Bankhead-Jones Farm Tenant Act, as amended, with respect to distribution of funds among the several States and Territories, shall be authorized to obtain funds in such amounts as may be determined from time to time necessary to expand loan-making activities to keep pace with the progress of Basin developments.
- D. The program of assistance authorized under the Act of August 28, 1947, as amended, (50 Stat. 869) will be accelerated within the Basin to promote the proper development and utilization of water on agricultural lands in the arid and semiarid areas. To make this program more effective, it is recommended that the limitation on expenditures for the construction, maintenance, operation, rehabilitation or financial assistance of any project shall be \$100,000 instead of the \$50,000 limitation as provided in 590Z-5 of Title 16 U.S.C. The Secretary shall be authorized to obtain funds in such amounts as may be determined from time to time to be necessary to expand this program of assistance to keep pace with the progress of Basin development.

## II.

To facilitate and assist in the readjustment of systems of farming by the development of farming resources and by providing facilities for the adoption of more efficient systems of farming based on the conservation and wise use of land and water resources in such areas of the Basin as may be designated by the Secretary, the Secretary shall supplement existing credit facilities:

- A. By making loans to farm and ranch owners and operators to carry out approved farm plans embodying farm development and readjustments in systems of farming.
  1. Loans for readjustments may be made for the purchase of livestock, equipment, and farm supplies; for farm and home operating expenses; for land improvement and the adoption of conservation measures, including drainage facilities; for the erection and repair of buildings and fences; for refinancing of debts; for the payment of taxes and water or drainage charges or assessments; for the purchase of a farm or ranch; for the enlargement of existing farm and ranch units; for the purchase of stock or a membership in the farmers' organization providing services essential to farming operations; and for other agricultural purposes.
  2. Loans for readjustment shall bear interest at rates comparable to rates charged for similar loans by the Federally sponsored credit agencies operating in the Basin, as the Secretary may determine.
  3. No applicant shall be eligible for a loan under the authority granted herein unless the applicant is, by reason of his character, ability, industry, and experience, capable of successfully carrying out the undertakings required of him under the loan proposed to be made under this authority and that credit sufficient in amounts to finance the actual needs of the applicant is not available to him on suitable terms and conditions from any other source serving the community in which the applicant resides.
  4. Such loans shall be adequately secured in such manner as the Secretary may determine. If in the judgment of the Secretary it shall be advisable, in order to preserve the security for any loan made under this authority, the Secretary is authorized to pay off or make payments on taxes, water or drainage charges or assessments, or any other liens which may be prior to the lien or liens securing the loans made under this authority.



5. Loans shall be repaid over a period of years in installments consistent with the ability of the individual borrower to repay out of farm income, in accordance with standards prescribed by the Secretary, but in no event shall loan repayment periods exceed forty years from the date of advance of funds: Provided, the Secretary may defer the payment of installments for a period of not to exceed five years to permit the completion of planned development and the readjustments in the farm program if he determines that the farm income will not be adequate to meet other required expenses and such installments.
  6. The Secretary shall provide, in connection with loans, for such technical guidance and assistance as he deems necessary to assist borrowers in developing and carrying out farm plans, mutually agreeable to the borrowers and the Secretary and may establish standards for the periodic review and revision of such farm plans and the degree of compliance required as a condition of granting loans.
- B. By making loans to organized groups of farmers to provide facilities and services necessary to enable farmers to participate in the Basin program of conservation and development of land and water resources.
1. Loans may be made to drainage or conservancy districts for the construction, enlargement, rehabilitation, and operation of facilities for the drainage of land suitable for agricultural purposes and for refinancing existing debts where such refinancing is necessary or desirable in connection with a loan for the above purposes.
    - a. Such loans shall be advanced only where a prior determination of the feasibility of the proposed project or projects has been made by the Secretary on the basis of detailed surveys and plans.
    - b. Loans shall bear interest at rates to be determined by the Secretary
    - c. To the extent possible under laws applicable to the districts, loans shall be repaid over a period of years on an installment schedule

consistent with the ability of the district to repay out of income in accordance with standards prescribed by the Secretary, but in no event shall the repayment period of loans exceed forty years from the date of the advance of funds; provided, the Secretary may defer the payment of installments during the installation of the drainage facilities and the development of the lands benefited thereby for a period of not to exceed five years, if he determines that the income of the district will not, during such period, be adequate to meet other required expenses and such installments.

- d. Such loans shall be secured in such manner as the Secretary may determine. It is anticipated that ordinarily in view of the nature of the districts, such security will consist of bonds backed by the taxing power of the districts.
  - e. No district shall be eligible for a loan under 1 above unless (1) the district cannot get credit elsewhere at a reasonable rate of interest and upon other reasonable terms; (2) the district is so organized and its management and policies are of such character as to insure the reasonable safety of the loan and the furtherance of Basin development.
2. Loans or reimbursable advances may be made to soil conservation and other conservation districts which are empowered to provide services to land owners and operators to carry on conservation and land development work, for the purchasing of equipment and facilities where there is a sufficient potential need for the services of such equipment and facilities to justify acquisition.
- a. Loans or advances under 2 above shall bear interest at rates to be determined by the Secretary.
  - b. The loans or advances under 2 above shall be repaid over a period which does not exceed the useful life of the equipment or facilities to be purchased with the loan funds, the ability of the district to pay out of income received from services performed, or five years, whichever period is the least.



- c. Loans or advances under 2 above shall be secured by a first mortgage on the equipment and facilities purchased with the loan funds. In addition, the district shall assign or pledge out of the income which it is to receive from the rental or use of such equipment and facilities a sufficient portion to insure the repayment of the loan within the prescribed repayment period.
3. The following conditions, in addition to the provisions set forth under each type of loan above, shall apply to all loans and advances made under 1 and 2 above:
  - a. The Secretary shall provide in connection with such loans for such technical guidance and supervision as he deems necessary or desirable to assist borrowers in developing and carrying out plans for the construction, maintenance, and use of facilities; the regular conduct of business; maintaining good membership relations; and for activities of a similar nature which vitally affect the borrower's business and obligation to the Government, and shall require compliance with plans so developed.
  - b. If any part of the annual sums made available for loans shall be obligated during the fiscal year for which such sums are made available but not disbursed or advanced during such year, such undisbursed or unadvanced funds may be disbursed or advanced by the Secretary at any time during the five fiscal years following the fiscal year in which obligated and may be advanced in a lump sum or in installments as determined by the Secretary
- C. In making loans as recommended in Sections A and B, the Secretary will:
  1. Utilize existing or appoint such local farmer committees as he may deem necessary to advise him in carrying out his responsibilities in making such loans.
  2. Require borrowers to refinance their loans when it appears they may be able to obtain a loan from private or cooperative sources for that purpose on reasonable terms and conditions.

3. Bid for and purchase at any foreclosure, or sale, or otherwise to acquire any property pledged or mortgaged to secure a loan or other indebtedness or advance owing under this authority, to accept title to any property so purchased or acquired, to operate or lease such property for such period as may be necessary or advisable to protect the interest of the United States therein, and to sell or otherwise dispose of such property so purchased or acquired under such terms and for such considerations as the Secretary shall determine to be reasonable. Property so acquired shall, notwithstanding that legal title to such property remains in the Secretary, be subject to taxation by the State, Territory, district, dependency, and political subdivision concerned in the same manner and to the same extent as other similar property is taxed.
  4. Apply the provisions of the Bankhead-Jones Farm Tenant Act, as amended, relating to the authority of the Secretary to compromise and adjust loan debts and the provisions of law relating to the authority of the Secretary to adjust and cancel debts of farmers (12 U.S.C. 1150-1150(a)). (The provisions of law relating to criminal offenses applicable to loans made by the Farmers Home Administration which are not in the process of being amended shall apply to loans made under this authority.)
  5. Make such expenditures as he deems necessary to carry out the provisions of this authority, including personal services and rents in the District of Columbia and elsewhere.
  6. Accept and utilize voluntary contributions and services from any source.
  7. Issue such rules and regulations and make such delegations of authority as he deems necessary.
  8. Initiate and carry out credit research.
- D. In designating the areas in which the loans authorized in Sections A and B may be made, the Secretary shall give principal consideration to whether the agricultural development programs recommended in this report are being retarded because the required amounts and types of credit are not available from other sources.



## ESTIMATED LOAN FUNDS AND ADMINISTRATIVE COSTS

As already pointed out, the cost to farmers of programs proposed in this report will be met in several ways, as follows:

1. From farmers' own resources. This will include investment of their time, use of their equipment, and a considerable amount of their own cash.
2. Loans from existing credit agencies. The federal land banks and national farm loan associations, production credit associations, banks for cooperatives, commercial banks, life insurance companies, and other available lenders will be expected to extend their credit service as far as practicable on a sound basis. The Farmers Home Administration may expand its loan-making activities to keep pace with the needs of the program.
3. Needs not covered by the foregoing sources will be met by credit under the special lending authority by the Secretary proposed above.

The only portions of this financing program requiring federal appropriations are the loan funds of the Farmers Home Administration and the special loans by the Secretary. The estimated amounts of loans that will be required during the 30-year period, in addition to the current lending rate of the Farmers Home Administration, are as follows:

Accelerated water facilities loans .....\$104,132,000

Special loans and accelerated rate of  
Farmers Home Administration loans .....\$210,430,000

Attention is directed to the fact that while appropriations for these loans will be required, the loans will be repaid and the funds reimbursed to the U. S. Treasury. These amounts, therefore, should not be added to the installation cost of the recommended program.

Some administrative expense will be involved in the accelerated credit program. On the assumption that it would be handled in connection with other similar activities of the Farmers Home Administration, the estimated additional salary and other expense cost would be as follows:

Accelerated water facilities loan program ...\$300,000 annually

Special loans and accelerated Farmers Home

Administration loan program .....\$710,000 annually

The foregoing estimates cover not only the cost of making the loans, but also servicing the loans outstanding. The loans in force will increase in number and amount during the active lending period. As repayments begin to exceed new loans, the servicing load will decline.



## RURAL ELECTRIFICATION IN THE MISSOURI BASIN

Extending rural electrification in the Missouri Basin is beset with problems that are not present, at least in the same magnitude, in other areas of the United States. In this region, sparse settlement, unusual farming hazards from highly unpredictable weather, and the acute shortage of generation and transmission facilities greatly augment and magnify the problems normally present in extending central station electric service. The accelerated multi-purpose development in the Basin also will require that particular attention be given to the details of coordinating an accelerated rural electrification program with the related programs of other agencies. Rural electrification problems peculiar to the Basin, moreover, will require additional study in order to develop the most helpful planning assistance for borrowers in behalf of completing the job of rural electrification.

## NATIONAL PROGRAM OF RURAL ELECTRIFICATION

The national program of rural electrification is aimed at providing the means for farmers and other rural residents to obtain the same conveniences and efficiencies for improving their social and economic life as are available to most persons in urban areas.

To this end, the U. S. Department of Agriculture, through the Rural Electrification Administration, makes loans for the furnishing of electric service to persons in rural areas who are not receiving central station electric service. Rural areas as defined in the Rural Electrification Act, as amended, include farms, rural nonfarm dwellings and establishments, and towns of no more than 1,500 persons. Loans may be made to persons, corporations, States, Territories, and subdivisions and agencies thereof, municipalities, peoples' utility districts, and co-operative, non-profit, or limited dividend associations organized under the laws of a State or Territory of the United States. In making such loans preference is given to States, Territories, their subdivisions and agencies, municipalities, peoples' utility districts, and cooperative, non-profit, or limited dividend associations. As of November 30, 1948, 95.7 percent of the funds loaned had been borrowed by cooperatives, 3.9 percent by public bodies and .4 percent by power companies.

All loans are self-liquidating within a period not to exceed 35 years, and bear interest at the rate of 2 percent per year. They may cover 100 percent of the cost of construction. These systems are financed under corporate liability, and not under individual consumer liabilities. Fifty percent of the loan funds made available annually by the Congress is allotted for loans in the several States in the proportion which the number of farms without central station service bears to the total number of farms in the United States without central station electric service as of June 30 each year. The allotment of the remaining 50 percent of loan funds is discretionary, except that not more than 10 percent may be employed in any one State or in all of the Territories.

Loans are primarily for the purpose of financing the construction and operation of rural electric distribution systems. However, where existing facilities are unable to provide adequate power, or where an over-all saving in the cost of power can be achieved, loans may be made for the construction of generation and transmission facilities. Loans also may be made to finance the wiring of the premises of persons in rural areas, and the acquisition and installation of electrical and plumbing appliances (Sec. V of the Rural Electrification Act). The latter type of loan for consumer facilities is made to distribution system borrowers for rel oan to individual consumers. Loans are not made for individual home generators.

Rural electrification borrowers are independent business enterprises. Their relationship with the Department is primarily the financial one of borrower and creditor. To assist borrowers in electrifying unserved areas and to safeguard properly the security of federal loan funds, advisory assistance is provided in connection with the financing and construction of rural distribution systems in accordance with established standards. In addition, borrowers are assisted where necessary in audits and accounting and with problems concerning the management and operation of the rural electric systems.

#### STATUS OF RURAL ELECTRIFICATION IN THE MISSOURI BASIN, JUNE 30, 1948

A big job of rural electrification remains to be done in the Missouri River Basin area (table ). The average of the percentage of farms electrified in the Basin was 56.9 percent on June 30, 1948, or almost 12 percent below the national average of 68.6 percent. Less than 24 percent of the farms in North Dakota and South Dakota and only about 44 percent of Nebraska's farms were receiving central electric service. About half the farms in Kansas, Missouri, Montana, and Wyoming were electrified. On the other hand, considerable progress has been made in achieving area coverage in Colorado and Iowa with approximately 80 percent of the farms receiving central station service on June 30, 1948. Connections in Minnesota were near the national average or slightly less than 70 percent.

Most of the rural electrification task already completed in the Basin has been accomplished since 1934. According to the 1935 U. S. Census of Agriculture, only 7.8 percent of the farms in the Basin were electrified on December 31, 1934. The Rural Electrification Act has been primarily responsible for the rapid progress of rural electrification during the past 14 years. Almost 72 percent of the farms electrified in the Basin States since December 31, 1934, were electrified by borrowers under that Act (table ). The proportion of farms electrified by borrowers since December 31, 1934, ranged from about 53 percent in Kansas to almost 87 percent in Nebraska. If progress continues at the present accelerated rate, electric energy should be available to all rural consumers in the foreseeable future.



Table 34.-- Number of Farms with Central Station Electric Service in the States in the Missouri Basin, June 30, 1948 <sup>1/</sup>

State	: Farms with Central : Station Electric : Service	: Farms without Central : Station Electric : Service	: Percentage : of Farms : Electrified
Colorado	38,009	9,609	79.8
Iowa	167,356	41,578	81.1
Kansas	71,161	70,031	50.4
Minnesota	130,378	58,574	69.0
Missouri	127,706	113,228	53.4
Montana	18,837	18,910	49.9
Nebraska	48,946	62,810	43.8
North Dakota	15,879	53,841	22.8
South Dakota	15,405	52,300	23.9
Wyoming	6,871	6,205	52.5
Total Average	641,548	486,886	56.9

<sup>1/</sup> Estimates are for each entire State.

Table 35.-- Percent of Farms Electrified from 1934 to 1948 by Borrowers under Rural Electrification Act

State	: Farms Electrified: : Dec. 31, 1934, to : June 30, 1948 <sup>1/</sup>	: Farms Electrified: : by REA Borrowers: : from 1935 to : June 30, 1948	: Percent of Farms : Electrified from : Dec. 31, 1934, to : June 30, 1948, : by REA Borrowers
Colorado	30,864	17,935	58.1
Iowa	135,309	96,393	71.2
Kansas	57,937	30,757	53.1
Minnesota	116,595	90,120	77.3
Missouri	111,813	84,504	75.6
Montana	16,069	9,716	60.5
Nebraska	39,402	34,106	86.6
North Dakota	13,911	10,430	75.0
South Dakota	13,466	8,337	61.9
Wyoming	6,344	5,351	84.3
Total	541,710	388,649	71.7

<sup>1/</sup> Estimate of number of farms electrified June 30, 1948, less number electrified December 31, 1934, according to the 1935 Census of Agriculture. Figures for each entire state.

The areas served by borrowers in the Missouri Basin are outlined in figure 23. Two main boundaries are shown on figure 23. One is the "power market area" boundary adopted by the Federal Power Commission in its "Power Market Survey" of the Basin. The other is the boundary of the watershed of the Missouri River. The "watershed" boundary is indicated by a heavy dotted line and the "power market area" boundary by a heavy solid line. The power boundary is most important for the purposes of assisting borrowers in coordinating their plans with power projects underway or contemplated under the Pick-Sloan Plan and with other programs in the Basin.

Within the "power market area" are 259 systems financed by the Department. Many of these systems have already made detailed engineering surveys of the area in which they plan to make electric service available to all rural residents. Those areas are bounded by "ultimate system boundaries" shown by legend designation of figure 23. A substantial number of the systems for which no boundary is shown also have embarked on ultimate system surveys. The remaining systems, many of which were recently organized, are expected to initiate such studies at an early date.

Table 36 represents a brief statistical summary of the status of the program in the States included in the Basin area as of November 30, 1948. As of that date, borrowers had been loaned \$535,347,135 to construct about 336,389 miles of line to serve 766,973 consumers. Approximately 217,181 miles of line serving 552,868 consumers were actually energized and 119,208 miles of line to 214,105 consumers were under construction.

About 485,000,000 kilowatt hours of energy were sold to ultimate consumers by these systems for the 5 months ending November 30, 1948. On June 30, 1948, farms comprised 76.8 percent of the connected consumers. At that time, borrowers were serving about 60 percent of the farms receiving central station electric service in the States located in the Missouri Basin area.

#### POWER USE EDUCATION

The extension of electric power to rural areas brings new services in the form of home conveniences and labor-saving equipment. Farm families need information on bringing water into the house, in the selection, care, and use of electrical equipment, and in resetting farm operations around electricity. Settlers on new irrigation projects will need help in the development of a complete farm.

As is the case with other suppliers, borrowers will play an important role in power use education. At present, 62, or 24 percent, of the borrowers' systems in the Basin are employing electrification advisors. Approximately this many more systems have taken action to initiate an educational program on the uses of electricity.



# AREAS SERVED BY REA-FINANCED SYSTEMS IN MISSOURI RIVER BASIN

Figure 23

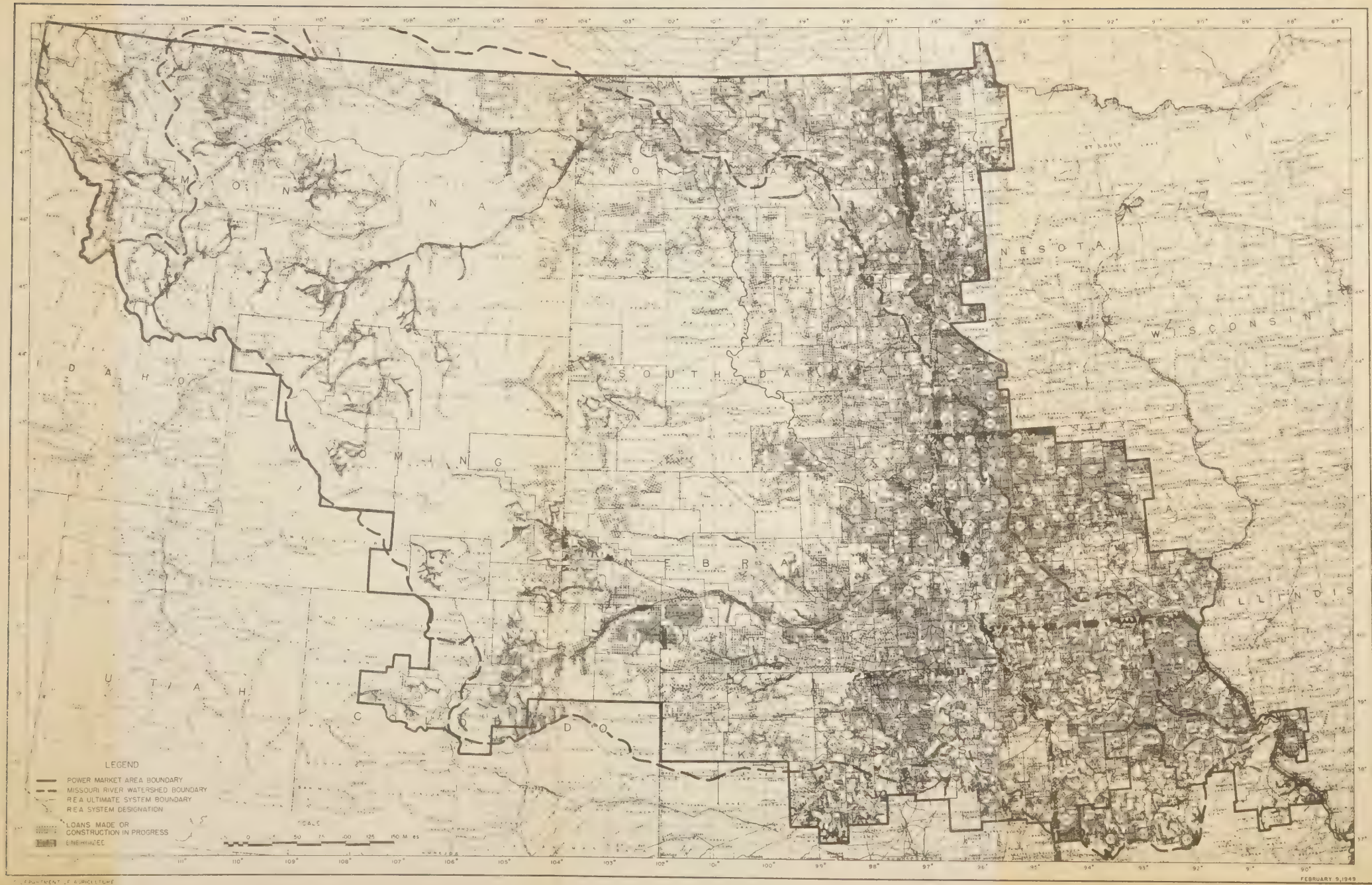






Table 36.- Status of Rural Electrification under the Rural Electrification Act in the States of the Missouri Basin 1/

	No. of	Est. Mi. of Line	Est. Con- sumers to be Con- nected	Mi. of Line	Con- sumers	Electricity Used by Con- sumers	% of Total	% of Total
State	Bor- rowers	Total	Loans	Con- structed	Con- nected	Con- sumers	REA Consumers	Electrified Farms
	(no.)	(000 Dol.)	(mi.)	(no.)	(mi.)	(no.)	which are	Served by
						(000 KWH)	Farms	Borrowers
							(pct.)	(pct.)
Colo.	22	29,050	17,458	44,768	11,597	35,693	56.0	47.2
Iowa	55	93,430	51,474	123,125	42,766	108,217	94.3	57.6
Kansas	36	49,609	35,604	68,343	20,319	41,139	85.1	43.2
Minn.	54	90,321	62,645	148,016	49,924	122,993	78.4	69.1
Mo.	47	97,625	57,857	180,447	37,126	130,042	69.7	65.1
Mont.	23	24,003	14,676	29,463	9,940	20,586	53.3	51.6
Nebr.	36	51,098	36,541	74,762	21,396	46,270	83.8	69.6
N. Dak.	23	54,667	30,175	42,090	11,373	18,516	71.2	65.7
S. Dak.	28	35,006	22,849	42,848	8,464	19,648	54.2	50.8
Wyo.	16	10,538	7,130	13,111	4,276	9,764	59.7	77.9
Total	340	535,347	336,389	766,973	217,181	552,868	76.8	60.2

1/ All data as of 11/30/48 except last two columns, which are for 6/30/48.

Electrification advisors work closely with county extension agents, vocational agriculture teachers, and State college specialists in showing farmers how to select, install, and operate electrical equipment, to adapt electricity to farm and home uses, and to determine the relative efficiencies of electricity and other power sources. Borrowers will be encouraged to intensify work in power use education to supplement the accelerated educational activities of federal and State agencies as contemplated in this report.

#### DEVELOPMENT OF ELECTRIFICATION IN NEW IRRIGATION PROJECTS

Individual farmsteads have to be developed from the ground up on new irrigation projects. It is probable that settlers could accomplish this development more rapidly and economically if power were available to them at the time of settlement. If groups of settlers decide that this power would be desirable, arrangements may be worked out with borrowers in behalf of making electricity available early in the development stage. In order to make this assistance available, however, groups of these settlers or some responsible public agency must certify that development will take place after lines have been constructed, and connection deposits may be required to secure the financial responsibility involved. This is a matter that must be worked out with each borrower, and, if adequate assurance of development and loan security is forthcoming, loans may be made available for advanced development.

The size and design of many borrower systems will be materially affected by the location and number of farms to be added by the development of new irrigation projects and the location and number of farms to be flooded by reservoirs from dam construction. The location and size of reservoirs, existing irrigated land, and arable land to be irrigated is outlined in figure 21. The necessary detail for fitting these developments into the design of individual systems will be incorporated in the "ultimate system studies" conducted by borrowers serving the affected areas. Borrowers will be kept informed as present plans for these developments mature and as new projects are authorized.

#### ESTIMATE OF FARM POWER REQUIREMENTS

The estimated power requirements for farm consumers for the States in the Basin in 1960 and 1970 are shown in table 37. These are based primarily on estimates developed by the Federal Power Commission in its publication entitled "Part 1 - Power Requirements, Power Market Survey, Missouri River Basin." The Federal Power Commission estimates, which were made for five major subdivisions of the Basin, have been adjusted to a State basis. In addition, results of economic appraisals and power requirement studies by borrowers in the area have been considered.



Table 37.- Estimated Farm Energy Requirements in the States in the Missouri Basin  
in 1960 and 1970 <sup>1/</sup>

	Average Annual KWH Consumption Per Farm <sup>2/</sup>		Total Number of Farms in the Basin States <sup>3/</sup>		Total Energy Requirements Assuming All Farms Connected to Central Station Service in KWH <sup>4/</sup>	
	1960	1970	1960	1970	1960	1970
					(000)	(000)
Colorado	4,600	6,000	47,618	47,618	273,804	357,135
Iowa	4,500	6,700	208,934	208,934	1,175,234	1,749,822
Kansas	3,800	6,100	141,192	141,192	670,663	1,076,589
Minnesota	3,600	6,600	188,952	188,952	850,284	1,558,853
Missouri	3,900	6,200	242,934	242,934	1,184,303	1,882,737
Montana	4,082	6,146	37,747	37,747	192,603	289,991
Nebraska	4,300	6,700	111,756	111,756	600,689	935,956
North Dakota	4,250	6,300	69,520	69,520	369,325	547,470
South Dakota	4,125	6,150	68,705	68,705	354,260	528,170
Wyoming	3,700	5,350	13,076	13,076	60,476	87,446
Total	4,056	6,379	1,130,434	1,130,434	5,731,661	9,014,169

<sup>1/</sup> Does not include power requirements for pump irrigation and rural nonfarm consumers.

<sup>2/</sup> Estimates based on the Power Market Surveys of the Federal Power Commission and economic appraisals and detailed power requirement studies of certain borrowers.

<sup>3/</sup> U. S. Census of Agriculture, 1945.

<sup>4/</sup> Includes 20 percent energy losses.

The total KWH consumption per farm is the sum of the estimated use per farm dwelling and the estimated use for operating farm equipment. Energy requirements for farm operations are weighted according to the proportion of each type of farm which is expected to be found in each area. There are wide differences in power needs for the different types of farm enterprises. For instance, range livestock farms use a great deal less energy than do dairy farms. Farm household power requirements are based on the estimated saturation for the various household appliances. It is interesting to note that there is only slight variance between States in KWH consumption per farm.

The total number of farms that are expected to be in the Basin States in 1960 and 1970 is equal to the number of farms in these States on January 1, 1945, according to the 1945 Census of Agriculture. It was assumed that the increase in number of farms due to irrigation will probably be cancelled by the trend toward larger and fewer dry land farms and the flooding of land by reservoirs. If there is a net increase or decrease in the number of farms, the power requirements will change in direct proportion. The estimated total farm electric energy requirement in each State is the product of the estimated total KWH consumption per farm and the estimated total number of farms, plus 20 percent energy loss from load centers to farms. It is assumed that all farms will be connected to central station high lines by 1960. Number of farms rather than difference in use per farm determines total power requirements by States. Total farm power requirements estimated for 1970 are almost 1,900,000,000 KWH in Missouri and about 1,750,000,000 KWH in Iowa. Minnesota, Kansas, and Nebraska will also have large energy requirements. Colorado, Montana, North Dakota, and South Dakota will require between 290,000,000 and 547,000,000 in KWH. Wyoming will have the lowest energy requirement of the Basin States.

#### NEEDS OF RURAL ELECTRIFICATION BORROWERS

The estimated needs of borrowers for rural distribution line to accomplish the electrification of the remaining unserved rural areas are expressed in miles of line and in dollars in table 38. The figures for miles of line were obtained by dividing the estimated total number of rural consumers without central station service by the estimated number of consumers per mile of line. The estimate of funds required is the product of the construction cost per mile of distribution line and the required miles of line. The per mile construction cost of \$1,700 is calculated in light of 1948 prices for material and labor.

The only reliable measures of unserved rural consumers are those of rural "farm" consumers. There are no data showing unserved rural "non-farm" consumers. Therefore, in estimating the total number of rural consumers remaining to be served, the assumption was made that the unserved farm and rural non-farm consumers remaining are in the same proportion as were the farm and rural non-farm consumers connected by borrowers during the 12 months ending June 30, 1948. Using these proportions, estimates of unelectrified farms based on the June 30, 1948, unelectrified farm survey were expanded to unelectrified rural consumers.



Table 38.- Estimate of the Number of Miles and Construction Cost of the Rural Distribution Lines which are Required to Extend Central Station Electric Service to the Remaining Unelectrified Rural Areas in the States in the Missouri Basin 1/

State	Rural Consumers without Central Station Service				Consumers			Distribution Line		Funds Required to Construct the Distribution Lines to Serve Unelectrified Rural Areas			
	Farms	Rural Nonfarm Residences:	Total	(no.)	Per Mile of Distribution Line	(no.)	(mi.)	(000 dollars)	(000 dollars)	Total Required <u>1/</u> 2/	Funds Available: 6-30-48 <u>3/</u>	Additional Funds Needed <u>1/</u>	(000 dollars)
Colorado	9,609	5,938	15,547	1.83	8,496	14,443	12,000	2,443					
Iowa	41,578	2,536	44,114	1.94	22,739	38,656	19,000	19,656					
Kansas	70,031	9,314	79,345	1.79	44,327	75,356	17,000	58,356					
Minnesota	58,574	31,923	90,497	2.01	45,023	76,539	24,000	52,539					
Missouri	113,226	27,514	140,742	2.53	55,629	94,569	33,000	61,569					
Montana	18,910	12,064	30,974	1.60	19,358	32,909	9,000	23,909					
Nebraska	62,810	14,195	77,005	1.86	41,401	70,382	19,000	51,382					
North Dakota	53,641	10,245	63,886	1.28	49,910	84,847	24,000	60,847					
South Dakota	52,300	29,706	82,006	1.59	51,576	87,679	18,000	69,679					
Wyoming	6,205	2,916	9,121	1.19	7,664	13,029	3,000	10,029					
Total	486,884	146,351	633,237	1.83	346,123	588,409	178,000	410,409					

1/ Does not include estimates of requirements for generation and transmission facilities, system improvements, headquarters facilities, radio and communications, acquisitions and consumer facilities.  
2/ Costs are calculated at 1948 prices for labor and material of \$1,700 per mile.  
3/ Includes carry-over of funds from fiscal year 1948, fiscal year 1949 statutory allotments, and fiscal year 1949 discretionary allotments.

In arriving at estimates of funds needed to construct distribution line to serve the unelectrified rural establishments, it was assumed that borrowers would make virtually all the connections in the States in the Missouri Basin. If private power companies become more active in the rural area concerned, less loan money will be needed.

Estimates of funds needed to complete rural electrification are equal to the estimates of funds required to serve rural areas as of June 30, 1948, less the funds available to borrowers on that date. The funds available to the borrowers in each State on June 30, 1948, comprised three distinct allotments. They were: (1) Carryover of unused funds allotted on June 30, 1947, for the 1948 fiscal year; (2) statutory allotments for fiscal 1949 on the basis of the relative proportion of the total number of unelectrified farms on June 30, 1948, and (3) discretionary allotments for fiscal 1949 based on relative need for additional funds. Discretionary allotments may be adjusted somewhat between States during the fiscal year if relative needs change.

Although the total funds available to borrowers in the Basin States were slightly more than one-third of the funds available to all borrowers, the need for additional money for distribution line construction is still substantial in most of the area. Six of the States concerned need over 50 million dollars. The total need is approximately 410 million dollars. This does not include an additional undetermined amount for generation and transmission facilities, system improvements, headquarters facilities, radio and communication, acquisition, and consumer facilities.

The speed with which funds now available for construction will be used depends on the availability and cost of materials and supplies, especially conductor, the availability of low-cost power to meet the rapidly growing consumption demands, and the availability of adequate administrative funds for servicing loans, planning construction needs, and coordinating the program with other developments in the Basin.

The natural difficulties of extending central station electric service are greatly magnified in parts of the Missouri Basin due to sparse settlement, unusual farming hazards and a severe shortage of generation and transmission facilities. In addition, there are many problems in maintaining liaison between the rural electrification program and the development of new power sources, a more adequate transmission system, new farms on reclaimed land, and a more intensive irrigation program generally. There is, therefore, a need for some special investigational and program development work to assist borrowers to integrate their plans with other phases of the over-all Basin development program.



## POWER POLICIES TO FURTHER RURAL ELECTRIFICATION

The major factor limiting the development of rural electric systems is the acute shortage of power and of transmission lines to rural system load centers. Accordingly, borrowers have a vital stake in the construction of generation and transmission facilities under the Pick-Sloan Plan. Existing federal laws give cooperatives and public bodies preference in the disposition of electric power generated by public hydro-electric projects. It is essential that these laws be continued.

Rural electrification in the Basin will be advanced by the development of its power potentialities to the fullest extent possible and economically feasible at such times as the power demands arise. This will require the generation of power by steam and other types of plants, as well as by hydro-electric installations. A substantial amount of non-hydro capacity will be necessary for alleviating acute shortages during the interim until more hydro capacity is available for carrying the backbone of the load. As the hydro capacity becomes more fully developed the steam and internal combustion capacity will be essential for "firming up" and for reserves.

It is also important that federal agencies supplying power to rural systems provide such power at the lowest possible wholesale rates.

In marketing the power produced by publicly financed projects, preference should be given to the needs of cooperatives, public bodies and other public or non-profit uses. In developing the power resources of the Basin, the transmission of power to the load centers should be provided as an integral part of the over-all development.

In establishing market boundaries of power developed under the Basin plan, it is essential that market boundary lines should not be drawn through a rural system area. Where a portion of a rural electric system lies within an accepted power market boundary, power produced under the Basin program should be available to all consumers supplied by the system concerned.

## RECOMMENDATIONS

It is of utmost importance that the planning of rural electrification systems be integrated with the power features of the Pick-Sloan Plan. Moreover, in carrying out this plan recognition should be given to the need for rural electrification. To insure the maximum possible coordination in these respects, to assist borrowers in developing plans for extending service to the more sparsely settled and economically unstable farming areas, and to make certain that activities under the national rural electrification program are properly related to the Basin-wide agricultural program set forth in this report, it is recommended that the Department of Agriculture undertake special investigational and program development work in the Missouri Basin. It is estimated that the necessary investigations and work can be completed within a period of two years at a cost of \$138,000.

It is also recommended that loan funds be provided through the annual loan authorizations to the Department to enable borrowers to complete the task of extending central station service to all unserved farms. It appears that the present method of loan fund allotment by States under the national program will provide adequate money to complete this task. If, at a later date, it is found that the national program does not provide funds for completing this task, it is recommended that the necessary funds be made available for this purpose through supplemental appropriations.



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